Spotlight.

ON COTTON R&D

Autumn 2018

Looking deeply at compaction

Lessons in weed management

Verticillium research critical focus

Australian Government

Cotton Research and Development Corporation

Bruce Finney

In the Spotlight

Welcome to the autumn edition of CRDC's Spotlight on Cotton R&D.

On behalf of everyone at CRDC I wish you a successful and safe harvest. The prospects for above average yields, despite seasonal challenges, are reportedly high. Picking results from early planted crops in Central Queensland have been excellent and boll loads in general are promising should the balance of the season be kind.

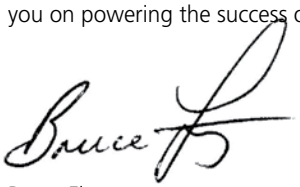
In this edition we draw attention to two important risk issues related to picking. Firstly, the issue of compaction, its impact on yield and the long-term effect it has on soil health. We talk to grower Ian Hayllor about what he found below the surface on his farm, and what some industry researchers are saying about compaction and its effect on water use and plant growth. Research since the 1980s continues to demonstrate that wet picking conditions and decisions on rotations, tillage, equipment and row configurations will have significant impact on subsequent yield potential and profitability. The challenge for growers, researchers and John Deere is what more can be done to reduce compaction?

Secondly, we highlight biosecurity and the new industry biosecurity campaign, 'be a good mate and stop it at the gate'. The campaign focuses on best practice management to stop many issues at the front gate, from rising herbicide resistance to the spread of disease. A single incursion of a pest to cotton could have devastating and long-term impact. Hence CRDC is supporting research into the high priority pests to ready the industry for incursions, should they happen. Right now at harvest there are many risks that can impact farms, a region or the industry. Have you put actions in place to protect your farm and your mates?

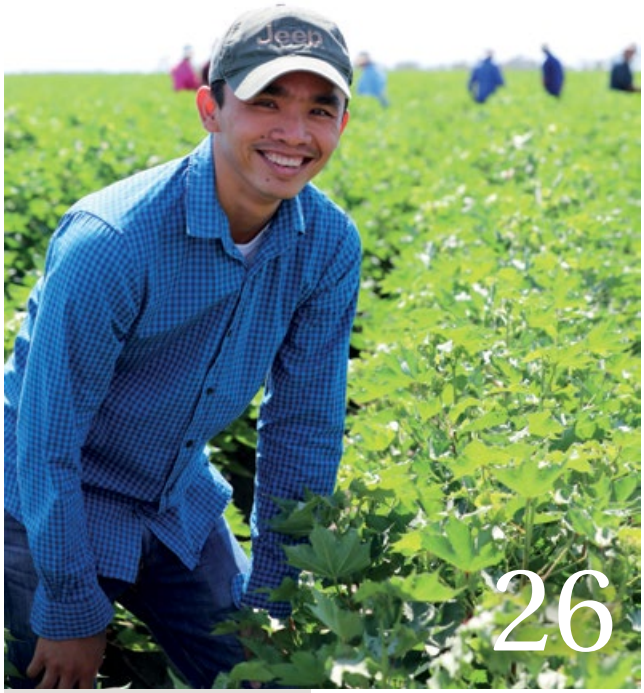
Spray drift impacts livelihoods, threatens future access to chemicals and the social licence for agriculture. CRDC will report in the next edition of Spotlight on work to deliver a robust solution that integrates effective policy, regulation, technology, research and training responses across agriculture. In this edition we hear from participants in a CRDC supported US study tour to identify learnings about the introduction and management of new herbicide tolerance traits. In light of the most recent spray drift impacts in Australia they equally implore growers and their staff, consultants and contractors to be aware of the information and tools available to them to help manage spray drift.

The digital revolution is underway in every part of the economy and CRDC is leading in the collaboration to enable opportunities for Australian agriculture to benefit. As leader of the Precision to Decision Agriculture project supported with funding from the Australian Government as part of its Rural R&D for Profit program, we seek to create policy and on-ground changes to help growers realise the potential for a 25 percent increase in the value of production. An example of the potential for new digital solutions to solve long standing industry challenges is CRDC's investment in the start-up FluroSat. Through utilising state of the art digital technology they are seeking to build tools for accurate near real time analysis of crop nitrogen status in support grower and consultant fertiliser decisions.

New CRDC directors were welcomed late last year, representing an exceptional level of expertise and experience. With a new five-year Strategic Plan being finalised and attendance planned at field days, conferences and regional Board meeting we look forward to engaging with you on powering the success of Australian cotton through world-leading RD&E.



Bruce Finney
CRDC Executive Director



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

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IMAGE MELANIE JENSON

ON THE COVER: Working together with researchers to learn more about Verticillium wilt and how to manage it – Andrew O'Connor and Janelle Montgomery (Page 27).

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

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

Cotton News

Features

Fast Facts

$20.3 billon

Production growth in Australian agriculture could be possible by unlocking opportunities through better support for digital agriculture (Page 7).

93

Percent of growers said they were supportive of biosecurity measures in a recent industry survey (Page 9).

50

Percent of last season's (2016-17) cotton crop was affected by compaction according to the Crop Consultants Australia survey (Page 12).

79

Percent of growers' business expenses are linked to businesses in their local area according to the latest CRDC Grower Survey (Page 18).

RENEE ANDERSON

The early planting window in Central Queensland is resulting in increased yields.

Early plant paying dividends

Picking in the Central Queensland 2017-18 season got underway on January 16, with pleasing early results. Many growers have taken advantage of the new Bollgard 3 planting window and have backed the results of recent CRDC-supported QDAF research on early planting. More than 60 percent of the region was sown during August 2017.

"To further our understanding of cotton production in the Central Queensland climate, the performance of crops planted throughout the new planting window from the beginning of August until the end of December is being benchmarked," says QDAF's Paul Grundy, who undertook the initial early planting research.

"Growth and development benchmarking has found that the performance of the early sown crops has again been very consistent with previous data – crops with excellent retention of bolls on compact plants making the most of cooler and traditionally sunnier conditions during spring and early summer.

"This season saw more cloud cover than in previous years during November but the absence of hot days and nights meant that crops performance remained intact compared to crops subject to cloudy weather later in the season when conditions are hotter and more humid resulting in extensive boll shedding."

With picking well underway many growers are smiling with consistent results across different fields and farms with yield estimates of 11 to 13 bales a hectare. With ginning set to begin in mid-February many growers are hoping for surprises on the upside with several people reporting their highest ever on farm module counts.

"We have started picking our early planted cotton crops, and yields have been sound," says Central Highlands' grower Neek Morowitz.

"Planting the crop in August is something different to get used to at first, but we've found the plant is growing well throughout the spring conditions when filling bolls. I am happy with the opportunity Bollgard 3 provides to plant earlier, and from my experiences over the past three seasons, I am always positively surprised with the crop."

Not only are many growers pleased with the extra modules along the sides of fields, this year has seen a colour change with pink modules. Not just a pretty sight, Central Queensland growers are helping to support the McGrath Foundation with Vanderfield donating 50 cents from every pink module produced.

Next generation: new challenges

WITH its reputation for advanced technology and continuous innovation, the Australian cotton industry draws on the expertise of a range of people, including on-farm workers and contractors, consultants and research scientists, to name a few. Yet there is the very real potential for disruptive new technologies to demand changes to workforce profiles of the industry.

This challenge raises the question 'what is the expertise – the personal strengths, knowledge, skills – that the future workforce needs to maintain and improve the cotton industry's strong production outputs in a competitive market?'

To answer this question, CRDC postdoctoral research fellow Dr Nicole McDonald is researching and developing practical strategies to support the cotton industry to attract and develop the next generation of expert workers. As part of this study, Nicole is seeking input from people throughout the industry.

"We want to support growers and other professionals in the cotton industry to ensure their future workforce is the best they can be, and that the cotton industry is the first choice for talented and capable young people making career decisions," Nicole said.

Tell us what you think…

- Do you work in the cotton industry either on-farm, or related to farm production (eg growers, farm hands, agronomists, consultants, scientists, researchers, extension officers, contractors)?
- Have you been working in the industry for five years or less?
- Do you currently employ someone working in the industry for five years or less?

If you answered "yes" to any of these questions, Nicole wants to hear from you.

For more:
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0403 204 199
nicole.mcdonald@usq.edu.au

Moree cottongrower Peter Glennie, US Consul General Valerie Fowler, Country Consular Coordinator Linda Daetwyler and CRDC's Allan Williams.

MELANIE JENSON

Top diplomat talks cotton research

THE US Consul General Valerie Fowler and Country Consular Coordinator Linda Daetwyler visited cotton industry trials at Peter Glennie's 'Norwood' late last year. Consul General Fowler leads the US Consulate General in Sydney and is one of the highest ranking senior officials of the US Foreign Service in Australia. The visit was a part of conducting rural outreach within her consular district, which includes NSW and Queensland. The visit was to learn more about the people, politics, industry, trade, and unique features of the region. CRDC R&D Investment Manager Allan Williams was a part of the gathering, which included representatives from the cotton and related agricultural industries. The US and Australia cotton research sectors collaborate through international partnerships such as Cotton Inc, and share information, technical expertise and research, host researchers, farmers and representatives on study tours. One recent exchange was last year's CRDC-supported Weeds Tour, which you can read about on Page 19.

Private sector funding for ag research

THE cotton industry now has a clearer picture of private sector investment in agriculture through the *Enhancing Private-Sector Investment in Agricultural RD&E* report with funding from CRDC and Dairy Australia.

Conducted by the Australian Farm Institute, the research aimed to obtain a better understanding of the role of the private sector in agricultural research, development and extension (RD&E) in Australia, with a particular focus on those factors or policies that are likely to enhance the role of the private sector in agricultural RD&E.

The report found that most of the private sector investment in agricultural R&D in Australia conducted by the companies included in the survey involves either experimental development or applied research, and there is only very limited private sector investment in basic research.

"The AFI report highlights the importance of both public and private sector R&D investment to the success of Australian agriculture," CRDC Executive Director Bruce Finney said.

"CRDC is actively growing collaboration with world-leading public researchers, agribusiness and entrepreneurs to solve industry challenges through bringing valuable new knowledge, products and services to the sector.

"Beyond the logical complementary roles in public and private R&D there is a growing innovation agenda where synergies are being found by bringing together the diversity of ideas, capabilities, intellectual property and resources for the benefit of the industry."

To download a copy of the report go to: www.crdc.com.au/publications

CRDC's Board at CRDC headquarters in Narrabri: Directors Rosemary Richards, Prof Les Copeland, Greg Kauter, Kathryn Adams, Bruce Finney (Executive Director), Richard Haire (Chair), Liz Alexander and Dr Jeremy Burdon.

ALL IMAGES ON THIS PAGE: MELANIE JENSON

Diversity in new Board

THE newly appointed CRDC Board met for the first time in November, with an induction of new Directors Professor Les Copeland, Dr Jeremy Burdon and Rosemary Richards.

Outgoing board members in Deputy Chair and St George cotton grower Cleave Rogan along with Michael Robinson, were also thanked and congratulated for their invaluable contribution to the Board over the past six years.

Led by incumbent Chair Richard Haire and CRDC's Executive Director Bruce Finney, CRDC's board also comprises current Directors Kathryn Adams, Liz Alexander and Greg Kauter, who have been returned for a second term.

"The role of CRDC is to drive innovation in the Australian cotton industry through investing in research, development and extension (RD&E) on behalf of cotton growers and the Australian Government," Richard said.

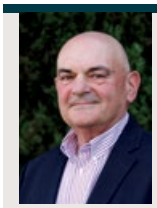
"Our role in working with the industry to set and invest in research priorities is critical – ensuring our industry remains profitable, sustainable and competitive.

"One of the great strengths of the CRDC Board has long been its diversity, with Directors each utilising a range of skills to help drive the organisation – and the industry – forward."

Upcoming CRDC Board meetings in cotton-growing valleys:
Narrabri: 19-20 June
St George: 7-8 November

Dr Jeremy Burdon has an international reputation in evolutionary biology combining interests and expertise in ecology, epidemiology and genetics to contribute solutions to problems in agriculture, including disease control, plant-breeding, weed biology and ecological sustainability. He has been recognised nationally and internationally with awards and honours.

Leading CSIRO Plant Industry for many years Jeremy has extensive experience in research management and commercialisation with cotton, grains, sugar and horticulture. Jeremy is a former GRDC director and member of Sugar Research Australia's independent Research Funding Panel. As Chair of the Australian Academy of Science's National Committee for Agriculture, Fisheries & Food, he led the production of a *Decadal Plan for Agricultural Science.*



Professor Les Copeland has been conducting research and teaching in agricultural and food science at the University of Sydney for over 40 years. His research on plant, grain and food chemistry, and the origins of the human diet, has resulted in over 150 publications and 34 PhD completions. He is a member of the Research Advisory Committee of the Australian Farm Institute, and Editor-in-Chief of the scientific journals Cereal Chemistry and Agriculture.

Les was Chair of the Cotton Catchment Communities Participants' Forum and a Director of the Australian Cotton and Value Added Wheat CRCs. He is a former Dean of Agriculture, and he was the Foundation President of the Australian Council of Deans of Agriculture.

Rosemary Richards is an agribusiness consultant with extensive experience in broadacre cropping, in particular oilseeds and downstream processing sectors. Rosemary is principal of Bowman Richards & Associates which undertakes strategic planning, supply chain management and trade and market access services. She also has extensive experience in biotechnology and was actively involved in the introduction of GM canola to Australia as CEO of the Australian Oilseeds Federation. Rosemary continues to be involved in biotechnology policy and advocacy through Australian and international representative organisations and also consults on trade and market access, commercialisation of biotech crops and business strategy. She is a passionate advocate for the agricultural sector and maintains close links with a range of agribusiness industry organisations.

FluroSat taking flight

AGTECH startup, FluroSat, has secured a $1 million seed investment, along with strategic support from the Entrepreneurs' Programme grant for Accelerating Commercialisation to further develop its state-of-the-art remote sensing technology that allows farmers to measure crop health 'from the air'.

CRDC supported the innovators of FluroSat through a series of start-up workshops last year. The 'cotton X-Lab' allowed the inventors to further incubate and grow their project.

"We are extremely grateful to CRDC and X-Lab for connecting us with industry – growers, independent and commercial agronomists – to get advice and run our ideas/questions about the prioritisation of the product features and money value those features have to the grower or agronomists," says FluroSat CEO Anastasiia Volkova.

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

"This start-up coaching has helped us with the formulation of business/product hypothesis and design of experiments to validate that in the quickest time possible.

MELANIE JENSON

FluroSat utilises drone and satellite imagery in infra-red bands to give users crops status information.

"It helped us in keeping focused, and defining our company strategy together with short/mid-term/long-term goals."

FluroSat utilises drone and satellite imagery in infra-red bands to diagnose crop stress and produce paddock nitrogen status maps. Growers and agronomists can calibrate these using nutrient tissue sampling to give a full spatial representation of the nutrient availability across fields with just a few tests.

"Our system makes crop growth predictions based on the mix of drone and satellite data and allow the users to customise it for their farms," Anastasiia said.

"This can be used to estimate nitrogen use efficiency and, down the track, quantify the return on investment looking at correlations between yield and applied nitrogen.

"We are building agronomic analysis tools to do the 'heavy-lifting' for crop managers.

"We believe that receiving the actionable insights required to manage a farm should be as easy as viewing your morning news feed.

"Our goal is to give growers and agronomists the cues to make decisions that directly affect ROI."

Getting on board the fourth revolution

AS business sectors and individuals across the world grapple with how to adjust, in rapid time, to the digital age, here in Australia agriculture and primary production joined forces through the Accelerating Precision to Decision Agriculture (P2D) Project.

Part of the Australian Government's Rural R&D for Profit Program, and led by CRDC, this project heralds a new era for Australian agriculture, as it is the first time all of Australia's Rural Research and Development Corporations have banded together to transform farm business management through the fourth revolution – digital agriculture.

"As far as we know, this project is the first of its kind, where an entire industry sector is taking a national approach to drive digital transformation in a coordinated and coherent fashion," said CRDC's Jane Trindall.

The summary report from the project shows that better support for digital agriculture could unlock opportunities for production growth to the value of $20.3 billon (25 percent increase on 2014-15 values) and highlights areas where Australia is lagging behind international competitors to utilise data and digital advancements.

"What we've found is that the industry's digital maturity is low," Jane said.

"We knew there were issues, which this draft report has uncovered, but we didn't have enough confidence in the definition of the problems to devise a plan to overcome the challenges.

"Through P2D we have worked with leading experts across this country's research institutions to narrow our focus and determine what needs to be done to make the most of opportunities.

"The key recommendations within this report call for leadership, new data policy, digital strategy and investment in data assets and digital literacy.

"Here in Australia, we're currently suffering from a significant lack of collaboration across different agriculture sectors, to combine our spending power and attract market solutions.

"That's got to change if we want to get private business, particularly technology suppliers, to the table.

"And we will also need better collaboration between industries to enable optimum data sharing for making smarter and more profitable decisions about all aspects of production, from inputs to pricing."

The final report is due to be released in March, along with three web-based tools to assist with delivery of solutions.

For more:
www.crdc.com.au/precision-to-decision

MELANIE JENSON

Cotton Conference pushing the boundaries in 2018

IT won't be long before it's upon us again, and organisers of the 2018 Australian Cotton Conference have set themselves the goal to beat the the attendance record set in 2016 of 1956 delegates!

Held at the Gold Coast Convention Centre from August 7-9, this year's theme "*Pushing Boundaries*" provides ample opportunity to explore the challenges and potential of an industry at the cutting edge.

International futurist Thomas Frey has been confirmed to kick off the Conference with a keynote address. Thomas's skills at predicting the future for business and industries will provide a thought-provoking start to the three days. Also confirmed as a keynote speaker is UN Peacekeeper and author Martina Jewell, with her fascinating life-threatening experiences and insights into teamwork and leadership. The full program will give attendees the opportunity to learn more about digital agriculture, dryland cotton production, global sustainability challenges and markets, succession planning and risk management, just for a start.

Conference Committee Chair and Theodore cotton grower Fleur Anderson says whether you're a grower chasing extra yield, a scientist pushing the limits or a manufacturer looking for new product performance, we're all looking for ways to move beyond the boundaries.

"From a grower's perspective, the Conference always provides that extra bit of information or advice that you take back to the farm to improve in some way.

"Together we will explore a huge range of issues, ideas and opportunities from a multitude of standpoints by not being afraid to have the difficult conversations and by hearing from world-leading experts from inside and outside the industry," she said.

The Conference is known for its full and varied program covering the latest research and industry trends, along with engaging keynote speakers with amazing stories. Mark Sowerby opened last year's conference, enthralling listeners with his quest to conquer one of the world's most difficult achievements – swimming the English Channel, and the life lessons that came from the experience.

"It really is an experience and a place to catch up with peers and friends as well."

With around 100 exhibitors, the Trade Show in the main hall of the centre is one of the largest in Australian agriculture, and is the gathering point for the critical networking and socialising that brings industry together during Conference, while showcasing new products and technologies taking Australian cotton to the next level.

The committee is determined to produce a Conference where there's 'something for everyone', where new delegates, families and the next generation feel welcome.

"All of that is made possible by the support of our sponsors and I am pleased to announce major commitments from Foundation Partners CRDC and Cotton Seed Distributors," Fleur said.

To register:
www.australiancottonconference.com.au
Exhibition sites:
Brian O'Connell on 0413 130 777

Award nominations open

THE cotton industry is full of them, so don't waste any time in nominating a deserving person for a 2018 Australian Cotton Industry Award!

Nominations close March 30, and nominating a person you feel has had a positive impact on the industry is easy by heading to the Awards website.

The annual Awards program recognises excellence and high achievement throughout the cotton supply chain, and concludes every year with an evening ceremony and dinner. Successful recipients of the 2018 Australian Cotton Industry Awards will be presented with their prizes on the night. The Awards' five categories are:

- Monsanto Grower of the Year
- AgriRisk High Achiever of the Year
- ADAMA Chris Lehmann Trust Young Cotton Achiever of the Year
- Cotton Seed Distributors Researcher of the Year
- Incitec Pivot Service to Industry Award

The recipients will be named at the cotton industry's premier annual event, the 2018 Australian Cotton Industry Awards Night, on August 9, at the 2018 Australian Cotton Conference on the Gold Coast. The night will include a sit-down dinner, drinks and dancing, with attendees invited to dress up in the 'Carnevale' theme for the night.

To nominate:
www.australiancottonawards.com

Biosecurity: My role or yours?

Who is on the lookout for exotic pests and diseases on our cotton farms?

MANY overseas insect and disease pests of cotton are a significant threat to the Australian cotton industry.

While the implementation of good on-farm biosecurity and hygiene practices is important for minimising the spread of both endemic pests (such black root rot, mealybugs and reniform nematodes), and exotic pests between farms and cotton growing regions, if new pests find their way to Australia or a cotton growing region, early detection and reporting is key to their successful eradication or management.

Recent changes to Queensland and NSW biosecurity legislation makes it much more explicit that biosecurity is a shared responsibility between all in the community. But when it comes to our cotton farms, whose responsibility is it to look out for our industry's high priority exotic pests?

The Australian Department of Agriculture and Water Resources recently conducted a survey into the social attitudes of the general public and farmers, including cotton growers and agronomists, towards biosecurity and practices they implement. It found, not unexpectedly, that there is a continuum of awareness, understanding and participation in regards to biosecurity within agricultural industries. Where people are on this continuum is driven by their biosecurity experiences, priorities, resources and compliance requirements.

One of the key things that the survey revealed was the importance of cotton growers and their agronomists discussing their on-farm biosecurity and plant surveillance activities, and determining roles and responsibilities, to ensure everyone who goes on the farm knows what their role is in helping guard against pests, weeds and diseases.

RENEE ANDERSON

Being a good mate: Central Highlands grower Daryl Mosley, 'Kingower' (with Cotton Australia Regional Manager Renee Anderson) ensures that all farm personnel, consultants, contractors and visitors are made aware of farm biosecurity requirements through proper signage to minimise the risk of spreading pests, weeds and diseases.

Who is watching the farm: the cotton grower?

The Department surveyed 32 cotton growers as part of this study. While nearly all growers had heard of the term biosecurity, and 93 percent said they were supportive of biosecurity measures, the survey found that there was a lower level of knowledge about biosecurity arrangements, measures and requirements among cotton growers than among other plant producers, and the study as a whole.

CottonInfo Biosecurity and Disease Technical Lead Sharna Holman from QLD DAF asks the question, "Is that because cotton growers are relying on their consultants when it comes to biosecurity?"

"The study recognises that cotton growers seek information and advice from their agronomists, and that they're much more likely than other farmers to consult with a private expert if they found an unusual pest or disease on the property (79 percent for cotton growers vs 32 per cent overall)," Sharna said.

"In fact, nearly all growers surveyed agreed that they'd report a suspicious new pest or disease, with the majority of these (67 percent) reporting it to a local consultant/agronomist."

Is biosecurity the agronomist's responsibility?

"The survey results suggest that even in

Industry guidelines

To see the full *Social attitudes and understanding of biosecurity to support market access and plant health surveillance* research report, go to the CottonInfo Biosecurity page (www.cottoninfo.com.au/biosecurity).

Additional resources also available at the CottonInfo biosecurity page:

- New state legislation for Queensland
- New state legislation for NSW
- Australian cotton industry's high priority pests
- Cotton industry's *my*BMP biosecurity checklist
- The Farm Biosecurity Action Planner to help you identify and prioritise the implementation of biosecurity practices relevant to your property.
- The Come Clean Go Clean biosecurity kit – information and guidelines to help you minimise and assess your risk of spreading pests, weeds and disease when visiting cotton farms.

the scientific and agronomic communities there is a continuum for the depth of knowledge and engagement with biosecurity and plant health general surveillance," Shana continUed.

"Those directly involved in plant health and related pests and diseases are well informed and have a deep and intimate knowledge, however even their interest could also be narrowly focused.

"The results from the interviews suggest that agronomists may not necessarily be as focused on biosecurity as growers think they are.

"With growers spending less time in the field checking for pests, weeds, disease and anything unusual, they may be assuming – without clarification – that their consultants have an awareness of the industry's high priority pests and the biosecurity requirements on farm.

"However, one agronomist said in his interview with the researchers: 'Agronomists haven't thought about biosecurity much with growers because they've not had an incursion – our role is to monitor'."

The upshot is that biosecurity is a shared responsibility, so it is important for growers and consultants to have discussions throughout the season about on-farm biosecurity and farm hygiene practices to help growers assess their on-farm biosecurity risks.

"It is important that both the grower and the consultant understand who is monitoring for both endemic and exotic pests that could have impacts to the farm and industry, and who is putting a biosecurity plan in place," Sharna says.

"If there are other farm workers who are often in the field, growers and consultants should consider providing them with information and pictures on the symptoms and appearance of industry high priority pests as part of their induction into the business and workplace."

What if I find something?

It is also important that both growers and consultants know what to do should they find a high priority pest or something unusual. Early detection and reporting to the Exotic Pest Plant Hotline (1800 084 881) is key to successful eradication and/or management.

All calls to the Exotic Plant Pest Hotline will be transferred to the relevant state department where an experienced person will ask questions about what you have seen, ask to see photos and may arrange to collect a sample. This person can help connect you with the appropriate expert for identification. These prompt reports to the Exotic Plant Pest Hotline ensure that the industry has the best chances to containing the spread of a potential exotic incursion.

For more
Sharna Holman
sharna.holman@daf.qld.gov.au

Be a good mate, stop it at the gate!

GROWERS play a key role in protecting Australia's agricultural industries from pests and diseases. Through implementing biosecurity and farm hygiene measures on your farm, you can help protect your farming business, your region and your industry from the introduction and spread of endemic and exotic insects, weeds and diseases.

A new pest or disease, once established on farm, can affect your business through increased costs for monitoring and changes in production practice; reduced productivity in yield or quality; or potential loss of markets.

Ensuring everyone on farm implements good farm hygiene practices is important for minimising the risk of entry and spread of pests, weeds and diseases around farms and regions which can impact on how we grow agricultural crops in the future.

What can you do on farm?

- Ensure all farm personnel, consultants, contractors and visitors are made aware of farm biosecurity requirements.
- Ask agricultural machinery contractors to clean down before coming on farm, or have a wash down pad if possible available for contractors and visitors to use when entering and exiting the property.
- Follow Come Clean Go Clean:
  - Wash down vehicles. Park on a clean wash pad where contaminants can be trapped.
  - Apply high pressure water to all surfaces to remove trash and mud, being sure to get into crevices.
  - Apply decontaminant to all surfaces
  - Rinse off decontaminant and clean down the wash pad
  - Don't forget to clean your boots and any tools you may bring into the field
- Remove all cotton volunteers and ratoon plants from all cropping and no-cropping areas to reduce carryover of pests and diseases.
- Monitor crops and fields regularly for signs of pests and diseases, particularly any new or unusual insects, weeds species or plant symptoms.
- Ensure all farm personnel, consultants, contractors and visitors are aware of the action to be taken in the event of identifying unusual pests or plant symptoms.
- If you spot anything unusual, call the Exotic Plant Pest Hotline 1800 084 881.
- Create a plan considering your farm's biosecurity risks, and implement measures to manage risk, including signage and parking areas for all farm visitors, appropriate washdown facilities, using farm vehicles to transport visitors around the farm, and arrangements with suppliers/contractors to ensure crop inputs, machinery and equipment are 'clean' before they are brought on to the farm.

Find more information and resources to help you implement good farm hygiene and biosecurity practices on your farm, visit the CottonInfo biosecurity webpage and *my*BMP Biosecurity module.

For more
Sharna Holman
sharna.holman@daf.qld.gov.au
www.cottoninfo.com.au
www.mybmp.com.au

Real time, broad scale insect monitoring on the horizon

Growers will receive timely and accurate information about pests in their region under a new cross-industry project.

As part of the Federal Government's Rural Research and Development for Profit Program, the *Improving plant pest management through cross industry deployment of smart sensors, diagnostics and forecasting* project will develop a mobile, cross-industry plant pest surveillance network to monitor and report the presence of pests that threaten major agricultural sectors across Australia in the cotton, grain, sugar, horticulture, wine and forestry industries.

The project will involve all plant RDCs including CRDC and is being led by Horticulture Innovation Australia (HIA).

The surveillance network will encompass:

- Advanced surveillance technologies, such as automated trapping and sampling, for detecting and monitoring a wide range of endemic and exotic plant pests. The project will also produce a number of flexible surveillance hubs with trapping technologies that can be mobilised in response to industry needs, such as in response to incursions;
- Improved pest forecasting through linking pest detection with weather forecasting and modelling systems;
- Fast, reliable and cost-effective means to identify pests, such as high volume data collation and distribution, and advanced molecular diagnostics for pest identification; and
- A cloud-based virtual coordination centre (AUSPestCheck) to improve information exchange on pests to producers, industry and government.

Producers will receive timely and accurate information about pests in their region, helping to guide management decisions, reduce pest resistance and demonstrate pest-free status to export markets.

As well as broadly improving biosecurity preparedness through improved surveillance, this project will include components that seek to specifically address biosecurity vulnerability in a number of industries including the Australian cotton industry.

Cotton specific research

Dr Wee Tek Tay, CSIRO, will lead a component that assesses the biosecurity risk of arrival, establishment and co-occurrence of *H. armigera* with dominant Cry1Ac resistance traits.

Dr Dean Brookes will review available information and capacity for the other high priority pests to ensure industry is informed ahead of any incursions. Dean will particularly focus on boll weevil, a highly damaging pest of cotton in the US, including adapting international eradication strategies for the Australian environment in preparation for any incursions.

Another target pest, brown marmorated stink bug (BMSB), has had detections in Australia but has not so far established. In the US, BMSB seems to be just as damaging to developing bolls as the green vegetable bug (already found in Australian cotton) and is a cause for concern. BMSB is also a vector of boll rot pathogens in the US. It is unclear how damaging this pest will be in the Australian environment.

"Pressure on cotton from BMSB is variable because the distribution of BMSB only overlaps with that of cotton in some areas," Dean said.

"BMSB is being controlled with insecticides in some cotton growing regions, and BMSB is likely to become more of a problem as the bug continues to spread."

Determining hosts

Dean will also investigate a proof of concept general method for identifying the host use of insects through molecular analysis of their gut content. Once pests such as BMSB are detected, quickly determining their potential host plant range is very important for planning any potential eradication strategies. Dean recently completed a PhD funded by CRDC on the green vegetable bug (*Nezara viridula*).

BRYCE SUTHERLAND

In the US, brown marmorated stink bugs seems to be just as damaging to developing bolls as the green vegetable bug.

CRDC's R&D Manager Susan Maas will be involved in the project, and says it is a great example of biosecurity collaboration between all the plant RDCs.

"To manage plant biosecurity in Australia we need all plant industries to be on board in projects such as this," she said.

"A new research partnership to address Australia's plant biosecurity was recently developed bringing together Plant Health Australia (PHA) and the nation's seven plant Research and Development Corporations, including CRDC.

"The group – comprising CRDC, GRDC, PHA, HIA, Wine Australia, Forest and Wood Products Australia, AgriFutures Australia and Sugar Research Australia – is coordinating and streamlining funding efforts and plans to increase biosecurity investment.

"Biosecurity is a massive challenge for all of Australian agriculture.

"With the Plant Biosecurity Research Initiative (PBRI) now in place, CRDC will benefit from more, large biosecurity collaborations like this one."

For more

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www.dpi.nsw.gov.au/about-us/media-centre/releases/2017/exotic-pest-alert-brown-marmorated-stink-bug

Shedding light on deeper issues

Darling Downs' farmer Ian Hayllor says understanding compaction on his farm made him realise it could be costing him very dearly in terms of dollars and soil health.

Ian's experience is supported by the fact that 50 percent of last season's cotton crop was affected by compaction according to the *Crop Consultants Australia survey*, with 16 percent reporting a yield reduction of more than one bale per hectare.

Ian says the cost to him could be in the region of 10 to 20 percent yield loss, which equates to 'a lot of money', not to mention what it indicates about soil health.

Last year Ian hosted a compaction workshop on his farm, which involved digging a soil pit in an irrigated field. He says what he saw was both enlightening and concerning. The workshop raised questions for Ian around the effect compaction is having on water and nutrient infiltration and efficiency, and how it can be avoided and repaired.

Extent of the issue

The workshop was part of research being undertaken through CRDC and CottonInfo with CSIRO's Dr Michael Braunack and USQ's John Maclean-Bennett.

"By talking with growers and crop consultants, it helps us determine the full extent of compaction issues across the industry. This is used to develop future research priorities to help guard against and manage compaction," the researchers say.

"By giving growers a look inside their soil we are bringing awareness to this issue and we can then work with growers to find solutions.

Ian was so amazed by what he saw occurring in his irrigated fields, after the workshops he dug another pit in unfarmed country to compare soil structure, which he said was 'like chalk and cheese'. He has also begun to move his irrigated fields to controlled traffic farming (CTF) which is already in use in his dryland fields. The Hayllors grow irrigated and dryland cotton along with cereals and legumes.

Suspicions confirmed

While always having had concerns about compaction and the impact of round bale cotton pickers, digging the pit on his farm confirmed Ian's suspicions, while also displaying a level of compaction which surprised him.

"To actually see what soil compaction looks like and the effects on the soil and correspondingly our crops was enlightening," Ian said.

"It helps you see what you have done, and it does take a bit to see, so having John and Michael there to show us the signs and explain the issue was really crucial.

"You could see the effect the compacted soil would have on root growth, water infiltration and water holding capacity.

"Looking down through the profile under wheel tracks and following the root channels, soil moisture was low, yet in adjacent uncompacted regions it was the opposite, so the effect on water holding capacity was crystal clear.

"This was an eye opener into how much we are affecting the soil in this way, and leads me to believe that we have been masking the compaction problem through our management strategies, particularly in irrigation by continually reducing irrigation scheduling deficits."

The effect on irrigation

The linkage between compaction and water has been under investigation at University of New England as part of a joint CRDC and CRC for Spatial Information project that's seen Dr Brendan Griffiths interrogating Goanna Telemetry capacitance probe data from the last few years.

"The results were surprising," Brendan said.

"The data set spans right across the industry, but what we did not expect was to see evidence of limited root activity below 60cm in roughly a third of the fields."

Closer examination of these sites has also led to some other interesting observations.

"We can broadly group many of these affected sites into two groups: the first shows no root activity below 60cm," Brendan said.

"Recharge of the profile at irrigation is fine, but we are basically growing these crops in only a small proportion of the soil profile, which may result in nutritional challenges in the future.

"In the second group we see sites that over the season don't return to the full point with irrigation.

"We believe that this is due to increasing the frequency of irrigation on soil that could be deemed to be more 'fragile' in its structural makeup, and is related to soil dispersion or slaking preventing water infiltration.

"Effectively we're losing pore space and this is a type of compaction."

An obvious question for growers is "are there solutions?"

Brendan says there are some instances in the data set where if irrigations are resumed either at or beyond the previously set refill points then the ability to reach the full point is regained.

"We also believe that putting the soil through several natural wetting and drying cycles could help, after all it is almost impossible to destroy the shrink-swelling property of our vertosols."

Are we com

Ian Hayllor believes compaction is literally and metaphorically a hidden issue on several fronts.

"By allowing compaction we are affecting root growth and making it harder for the plant's roots to access water and nutrients," he says.

"I believe we have been masking the effects of compaction with smaller irrigation deficits because we are decreasing our soil water holding capacity and trying to attain higher yields in the process.

"This was brought home to me after last season's heat and dry conditions."

Last season was a hard one for many climatically, and Ian believes it is in these testing times we may be paying the price of compaction. After record yields on his farm in 2015 and 2016, 2017 turned out to be a challenging and disappointing season for many

MELANIE JENSON

pensating?

growers due to the long, hot and dry summer.

"Last season we had poor yields and even though there were climatic reasons, you ask yourself, how much is compaction and how much is the season, and it made us want to find out more about the effect compaction is having and moving to alleviate it in our irrigated cropping system.

"I believe as an industry, and myself as an individual grower, we have underrated the effects of compaction.

"We could be looking at a 10 to 20 percent yield loss due to compaction, which adds up very quickly to a lot of money."

Researcher Mike Braunack agrees with Ian, saying "Compaction is the hidden disease: it is present but not seen".

"The industry has been growing very high yields over the past couple of seasons, so the attitude is that compaction is not an issue," Mike said.

"Last season's yields were down, and it is usual to assume this was due to climatic conditions, not the fact that those hot and dry conditions exacerbated the effect of compaction because roots cannot extract water or nutrients from the soil.

"Growers need to consider if they just take for granted that they have had to apply more nutrients or water more frequently to grow high yielding, high quality crops, but if their soil profiles were non-constrained it would be interesting to see what the yield potential could be."

The compaction near the soil surface can be managed, however, compaction deeper is very difficult, if not impossible to manage.

No benefit in wider tyres

While the research highlights that controlled traffic farming is the best defence growers have for minimising compaction, Mike said growers often ask about the benefit of wider tyres in reducing compaction, when "all the tyres do is reduce surface ground pressure enabling machinery to traverse wet soil when this should not occur".

"Basically wider tyres provide mobility and as the axle load has not changed compaction can still occur at depth.

"The compaction near the soil surface (top 15cm) can be managed, however, compaction deeper (30 to 60cm) is very difficult, if not impossible to manage.

"One analogy is when we travel over soft sand we let tyres down to increase the surface area, this reduces surface ground pressure which allows the vehicle to traffic loose sand, the invisible bit is the stress that occurs at depth causing dense sand."

Result of the system

All the researchers are in agreement on certain issues: compaction is an inevitability of our current cotton production systems.

Evidence of compaction can be seen in fields years after the event which caused it occurred. Remediation is possible, but can be extremely costly and, like so many other aspects of our industry, to avoid compacting soils in the first instance is a better strategy than having a suite of fixes.

"I would really recommend digging a soil pit," Ian Hayllor says, "we can learn so much about our soil this way, I am really pleased I chose to be a part

of this research, it's been an eye-opener, and I hope it is for the rest of the industry too."

Potential compaction mitigation strategies are being assessed based on information from the long-term trial being run by NSW DPI's Guna Nachimuthu at ACRI. The impact on soil compaction of rotation and tillage options in this trial has been investigated in collaboration with the UNE team of Dr Oliver Knox and Yui Osanai.

"The long term rotations at ACRI have a combination of minimum and maximum tillage treatments as well as cotton-cotton and cotton-wheat rotations with and without maize," Yui said, "and we've been fortunate to have access to the site to evaluate the soil conditions pre-plant, in crop and post-harvest."

This work has been part of a CRDC project that has just completed its final series of field assessments, but Yui is keen to share some of the findings to date.

"Basically what we've seen is compaction from traffic is evident throughout the season and is worse in the most heavily wheeled furrows," he said.

"Tillage choice can alleviate some of this compaction, but only in the top zero to 15 cm of the soil, which corresponds to the depth of the cultivation."

Soil health and compaction are issues for both dryland growers and irrigators.

MELANIE JENSON

The 2016-17 Crop Consultants Australia Qualitative Report shows compaction affected 50 percent of the crop, with 16 per cent impacted by more than one bale per hectare.

With regard to rotational options, Oliver said "Under the continuous cotton rotation, we've noticed that the inclusion of maize improves the soil structure, lowering the penetrative resistance of the soil, but we should stress that this improvement was small over the short term assessed to date".

Guna's runoff monitoring results also suggest a crop sequence such as cotton-wheat-maize could reduce runoff and enhance infiltration in the furrows of minimum tillage plots. Growers could potentially look for more crop diversification while selecting the rotation crops from traditional two year cotton-wheat rotation.

Implications for growers

"The upshot is that traffic and rotations are going to impact on your soil structure and that while we might alleviate some of this with tillage, the impact can be small and there will be some farmers out there that will want to weigh that up against the potential for loss of soil carbon and the subsequent implications for soil structure," Oliver said.

"However, the other important component of the system to consider is yield."

Oliver said Guna's research averaged half a bale per hectare more off the minimum tillage plots in the trial and the researchers have been putting this down to improved water recovery by the crop. Rotational effects have varied between seasons, but some slight improvement in yield has been seen where maize was added to the rotation, because increased organic returns is slowly improving soil structure.

Lessons from the long-term trial imply that soil structural improvements can be made, but that the results may take a long time. While it takes a long time to realise the benefits of soil structural improvements, soil structural damage can occur in a single operation. Growers need to be mindful of this while planning their pre-planting, in-crop, harvest and post-harvest operations.

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Going global for answers

Soil scientist Dr David McKenzie recently travelled overseas to investigate the latest techniques and technology for visually examining and evaluating soil compaction.

Leaders in the field from around the world came together in Ireland for a meeting of the International Soil and Tillage Research Organisation (ISTRO) Working Group on Visual Soil Examination and Evaluation (VSEE). David attended the workshop on behalf of CRDC.

"My focus was on discussions about improvement in farmer-friendly field techniques and resources for compaction evaluation in top-soil and sub-soil," David said.

"It was interesting to learn about adjustments required when comparing compaction severity scores in moist soil with measurements obtained under dry conditions, through the in-field soil assessments."

The event was also an opportunity to review the currency of Australian industry manual *SOILpak* on the international stage.

"Soil assessment and management continues to be a critical issue for Australian cotton growers," David said.

"Of particular importance is soil structural form (compaction severity) and structural stability in water as these factors affect the ability of soil profiles to accept and store water in farming systems constrained by drought.

"Soil structural quality also is strongly related to severity of waterlogging when conditions are wet, which can cause major yield losses.

"Apart from the plant growth constraints of reduced water holding capacity and aggravation of waterlogging, soil compaction adversely affects the growth of beneficial soil flora and fauna."

David says that despite a proliferation of 'high-tech' procedures such as landscape modelling based on EM survey data, the most accurate and cost-effective way of comprehensively measuring soil structural condition/compaction throughout the root zone of cotton plants and associated rotation crops is direct assessment in soil pits and/or spade profiles.

SOILpak contains descriptions of soil structure assessment techniques that are still relevant to growers and their advisers and its procedures were shown to have ongoing credibility at the methods comparison workshop David attended. However he said field demonstrations of European methods of VESS, included a mobile phone app, and extension products developed recently in Ireland and France have farmer-friendly flow-charts and graphics that are easier to follow than in *SOILpak*.

"Although *SOILpak* structure assessment procedures for cotton growers in Australia are still relevant, and compatible with GlobalSoilMap depth intervals for mapping using 'traffic light' colour coding, the way in which they are presented may need updating," David said.

"An eBOOK format that allows rapid introduction of new soil assessment/management ideas and inclusion of 3D instructional videos would be a great resource for Australian growers."

R&D Manager Allan Williams oversees soil research for CRDC and said it is important that soil information is available to Australian growers in an up-to-date and accessible form.

"Compaction, and to a lesser extent, sodicity are issues we are focussing on," Allan said.

"We are supporting a number of research projects either directly or indirectly examining compaction and soil structure, and this includes examining the relevance of extension information and tools available to growers."

Dr David McKenzie

BELOW:
David travelled to Ireland to meet with world leaders in soil science to look at compaction evaluation methods.

MELANIE JENSON

Growers survey for better benchmarking

CRDC has just revealed its new look Grower Survey, which this year includes a booklet with results at a glance, along with a new interactive 'digital dashboard'.

The digital dashboard allows growers to see key information easily and drill down into regional and farm size specifics. The 2017 survey outlines industry practices based on responses from just over 200 growers during the 2016-17 season, with an average of 624 hectares per grower under cotton, representing 21 percent of the total farm area.

The survey showed yield suffered at the hands of a cool start and long hot summer, with (average) yields of 9.88 bales per hectare for fully irrigated, down to .95 bales/ha for dryland. In fully irrigated crops, 298kg/ha of nitrogen and 7.88ML/ha was applied. Partially irrigated crops received 97kg/ha of nitrogen and 1.43ML/ha.

Across the board growers are working under industry best practice, with more than 90 percent using integrated pest management to preserve beneficial insects, while overall 57 percent follow industry thresholds for all spray decisions.

While Australian cotton is well regarded for quality and low contamination, the survey showed 85 percent reported at least one quality discount, with leaf, colour and high micronaire the most common.

As well as surveying farm inputs, yield and practices, the survey also found that cotton growers are contributing to the local economy, with 79 percent of growers' business expenses linked to businesses in their local area.

The new look survey comes after a CRDC review of the aims, purpose and design. It was developed by a working group including CRDC, Cotton Australia, researchers and others. The overall survey program is guided by CRDC's Monitoring and Evaluation Framework and supplemented by research questions relevant to the seasonal conditions. This survey gathered mid-term assessment of growers' views of CRDC's performance against the Strategic R&D Plan 2013-18.

Growers completed a 20-minute survey which covered a range of topics related to their cotton growing experience on and off-farm.

"The results give CRDC a picture of the effect of research on practice and highlights strengths and weaknesses in areas of extension and uptake," CRDC General Manger R&D Investment Ian Taylor said.

"For growers, it also gives a virtual look over the fence, allowing them see what others are doing well or could do better."

CRDC will continue with the new survey format this year and are keen to see more growers come on board.

"We've cut back on the time needed to complete the survey, to encourage more participation, and we are also trying to provide greater value back to growers by enabling them to benchmark and compare their practices with others," Ian said.

"We would really like more growers to become involved in the survey, as the more responses we have the better picture we can form to help the industry prioritise grower needs, to lead to increased sustainability and economic outcomes for individuals and the industry."

The 2018 Grower Survey will open in June 2018. Details on how growers can participate will be provided in the Autumn edition of *Spotlight*.

The 2017 survey digital dashboard and results booklet can be accessed at www.crdc.com.au/growersurvey.

How can we best manage new herbicide traits in our cotton crops?

A CRDC study tour to the Mississippi Delta and Texas in the US last year revealed some sage lessons for Australian cotton growers.

This tour was timely, with industry discussion on new herbicide tolerant traits ramping up ahead of the 2021 release of Monsanto's XtendFlex and with Dow AgroSciences' current engagement with industry on the potential for Enlist trait technology.

In the US, varieties that are tolerant to dicamba, glufosinate and glyphosate (Monsanto's XtendFlex trait technology) and varieties that are tolerant to glyphosate and 2,4-D (Dow's Enlist trait technology) are now commercially available, supported by propriety low volatile formulations of dicamba and 2,4-D. However the release of dicamba-tolerant cotton and soybeans in the US in the 2016-17 season sparked reports of significant off target drift damage in several states in the Mississippi Delta, with Arkansas recently banning use of dicamba during Summer. Particularly affected has been soybean crops, which are as sensitive to dicamba as cotton is to 2,4-D.

Take home message

The take home message from the US tour was that these new technologies are not silver bullets, rather they are extra shots in the magazine for growers to deploy if their weed spectrum warrants it and they will require an increased focus on stewardship. The safe introduction of Group I herbicide tolerance traits and accompanying low-volatility formulations into the cropping system is crucial for the reputation of the Australian industry.

In Walgett in North-West NSW, several members of the Walgett Cotton Growers Association became interested in what they were hearing about the introduction of the new technology in the US and wanted to learn more. The CGA approached CRDC with a proposed study tour to meet US researchers, industry representatives, growers and regulators in an effort to improve understanding on US herbicide resistance and weed management issues, gain insight in to the drift reports and learn from the rollout and implementation of the new technology.

CRDC supported this initiative and the need for the Australian industry to be prepared for the new technology, and sought broader industry involvement, with Monsanto and Cotton Australia also coming on board. As well as Walgett CGA representatives, the tour was expanded to include the TIMS Committee and TIMS herbicide tech panel members, CottonInfo and CCA representatives, in addition to Cotton Australia and Monsanto staff.

CottonInfo Weed Management Technical Lead Eric Koetz of NSW DPI said the trip highlighted the importance of diversity in both crop rotation and weed control tactics and the Australian Herbicide Resistance Management Strategy (HRMS).

"Glyphosate-resistant Palmer amaranth continues to drive the US weed system, and dicamba and 2,4-D tolerance traits have improved weed control for US cotton systems," Eric said.

"The extension message to US growers is to keep group D and lay-by chemistry in the system, however many are relying on straight dicamba or 2,4-D and glyphosate.

"This is very concerning, because if both the new traits are being adopted as a simple system similar to Roundup Ready cotton, and growers just use the dicamba or 2,4-D products in isolation (drop residuals), they'll probably only have five years before resistance occurs, in addition to glyphosate resistance.

"The potential to develop resistance to these Auxin herbicides in such a short time frame is confronting when you consider that they are 50 to 60 year old chemistry with only isolated resistant populations reported to date.

"We certainly don't want to be facing that scenario in Australia."

Drifting off target

The other scenario Australia doesn't need is potential off target damage from dicamba adding to 2,4-D issues growers are dealing with at the moment.

"The Australian industry can learn from the US experience, regarding the introduction of Group I herbicide tolerance traits and accompanying low-drift formulations," Eric said.

Eric notes that successful

implementation appears to be where the stewardship package included strong training programs targeted at growers, consultants, applicators (contract and farm hand) and others in the supply chain (including equipment providers).

"Some of the risks that will need to be addressed will be the use of non-low volatile dicamba formulations not registered for OTT use, and ensuring the label is suited to Australian cotton conditions including considering aerial registration (there is no aerial registration for dicamba in the US)," Eric said.

Monsanto Australia has indicated a firm commitment to work with the Australian cotton industry over the next four years to implement a strong stewardship framework that proactively mitigates resistance and drift risks to avoid unnecessary regulation or loss of social licence.

Cotton Australia's Nicola Cottee said there were some clear take home messages from the tour.

"The introduction of XtendFlex and Enlist traits has greatly improved the ability to control Palmer amaranth in US cotton crops, however the introduction of these technologies has introduced significant stewardship and potentially social licence risks to the industry.

"The Australian cotton industry is positioned to develop a stewardship framework for XtendFlex cotton which pre-emptively addresses the technical, cultural, and policy challenges that are currently driving resistance and spray drift issues in the US system.

"The US situation highlights that product stewardship at a grassroots and industry level is essential for the provision of assurances in respect to technology longevity, on-farm productivity and profitability, industry sustainability, and the long-term right to grow cotton."

In addition to weed management and trait/herbicide stewardship, the group also noted:

- Increasing Bt resistance in the US, resulting in reliance on Vip gene.
- The Lygus/thrip trait is at field trial stage.
- Verticillium wilt management had improved with the introduction of Fibremax (Australian germplasm).
- Research on cover cropping, soil nematodes, and other insects.

Resistance on the rise

Cotton industry weed surveys show 'alarming' levels of glyphosate resistance in problematic weeds in cotton farming systems.

CottonInfo Weeds Technical Lead Eric Koetz says the resistance levels that are coming out of screening remain at high levels between surveys. The weeds of most concern are sowthistle, fleabane, feathertop Rhodes grass, windmill and barnyard grass.

"These five weeds have been identified as some of the most problematic in the cotton farming system," Eric said.

"The high resistance levels tell us that if we rely on glyphosate alone, the big message for growers is that if we continue down this path, we will lose this chemistry for weed control across all farming systems.

"We need diversity in our weed control, which includes both herbicide and non- herbicide control tactics."

The random nature of surveys and sampling of different cotton fields between years explains in part what would appear to be a decline in resistance levels. The 2017 survey was a smaller sample size than previous years, however there are still alarming levels of resistance.

Why these weeds?

The five weeds showing high levels of resistance are all prolific seeders, thrive in no till systems, produce mobile seeds and all have capacity to develop resistance.

CRDC R&D Manager Susan Maas says while concerning, these results certainly weren't a surprise.

NICOLA COTTEE

For cotton growers, Palmer amaranth is the major problem weed in the US, with new herbicide tolerant traits having been developed to cope with rising resistance.

"The industry continues to identify these weeds as being particularly challenging due to their shared characteristics.

"The herbicide tech panel annually review industry practices as part of providing recommendations for Herbicide Resistance Management Strategy.

"While there has been some increases in use of residuals, particularly in crop, the 2016-17 survey found that about a third (22 percent fully irrigated, 33 percent dryland) of the cotton crop relied on glyphosate as the only option.

"While the reliance of glyphosate in cotton is concerning, it was good to see that the majority of growers are using more than two non-glyphosate tactics in their fallow, as outlined in the Herbicide Resistance Management Strategy."

2015 Weed Survey Results	% Resistant	% Susceptible
Sowthistle	22	78
Fleabane	97	3
Feathertop Rhodes grass	20	80
Windmill grass	95	5
Barnyard grass	72	28
2017 Weed Survey Results	**% Resistant**	**% Susceptible**
Sowthistle* (6 populations only)	10	90
Fleabane	75	25
Feathertop Rhodes grass	35	65
Windmill grass	60	40
Barnyard grass	65	35

John Cameron says the 'easy years' are behind us in terms of weed control, and how farmers behave from now on will 'determine our fate' in terms of our ability to control weeds and manage resistance.

Now is the time to take control

John is the Chair of the TIMS committee on herbicide resistance and also farms on the Darling Downs in South-East Queensland. He is a well-known advocate for improving herbicide use in terms of resistance and drift and was a part of the weeds study tour to the US to help better understand the challenges that lay before us.

"We've had glyphosate for 20 years now and it, along with other herbicides, is still the preferred method of weed control," John says.

"Worryingly, scientists gave us a 20-year period for use of this product before we would start to see any resistance, so the future is well and truly in our hands right now.

"What was really rammed home to me is that chemical companies and the trait providers are creating products in response to issues we have created.

"I don't see it as a good thing to have had to put these new dicamba and 2,4-D traits into the new varieties – it has come as a result of what growers are doing.

"At the end of the day if we as growers and an industry don't take responsibility we are going to be in strife."

John said while multiple group resistance in Palmer amaranth was the main problem in the US, farmers they visited who didn't have palmer amaranth were using a whole range of control tactics, and likens this to the need for Australian growers to do the same.

"All the guidelines we need to follow in Australia are in the Herbicide Resistance Management Strategy (HRMS)," he said.

"We can't keep taking the easy option of just using glyphosate or single modes of action.

"We must use all the tactics in the tool bag, or we could be in the same boat as the US within three years, as we see resistance in both grass and broad-leaved weeds.

"If you go back three or four years reports of new weeds becoming herbicide resistant were big news, now it doesn't rate a mention as it is becoming more common, and it could be very common if we don't stand up and put some effort in.

NICOLA COTTEE

John Cameron (right) talking weeds, resistance and drift in the US.

"We've got the bed that we've made for ourselves to lie in and we've got to work through that.

"In Australia we are probably in a better position in terms of resistance in weed species like amaranth.

"It is definitely a weed we do not want here, and growers should be wary of or avoid buying cotton pickers from known amaranth areas."

On his own farms, John is focused on adhering to the HRMS, and uses a range of methods to ensure there are no survivors. He is a big believer in the hoe.

"The beauty of a weed is that if it doesn't set seed, then that is the end of that generation, it's not an ongoing problem," he says.

After spraying weeds, he will check for survivors and use WeedIT to eliminate escapees and any coming up to seed head stage that need attention. He will also use hand chipping and says it is vital to control the whole farm – roads, channels, edges, as those seeds make their way into the paddocks.

"As you drive around the farm if you see a weed still alive that shouldn't be, get out and take it out," is his advice, along with having plants tested for resistance.

"I had preliminary tests done where we thought we could have problems and now I think I do have problems – we are getting more sowthistle that is not being controlled by glyphosate."

Getting the drift

"If farming as an industry doesn't sort out spray drift someone else will sort it out for us," John says.

"Even though all the technology, science and information is there for us, it falls down in the implementation stage.

"Products don't mysteriously drift – we are going about something the wrong way.

"Control of the operation rests with the business owner and they are the ones responsible.

"There are plenty out there that don't have off-target movement, so it is possible to avoid.

"We are still in control at the moment, but if we don't address drift we may end up out of control and the consequences don't bear thinking about.

"Given what we are seeing in Australia in regard to increasing resistance and drift, I really can't say with any confidence that we are ready for the introduction of dicamba-tolerant cotton to the system."

For more

Herbicide Resistance Management Strategy

www.crdc.com.au/publications/herbicide-resistance-management-strategy

Farming into the future

Walgett Cotton Growers Association vice-chair Bernie Bierhoff farms in the Walgett/Rowena area of North-West NSW, growing winter and summer crops, dryland and irrigated cotton.

He is concerned about both herbicide resistance in weeds and herbicide drift, which both occur as a result of poor practice. Bernie was one of the Walgett CGA who collaborated on the US weeds study tour with CRDC.

Bernie said the Walgett CGA wanted to get a better handle on the effect on the farming system of the new herbicide resistant varieties and investigate the reports of widespread damaging drift that came on the back of their release.

"We know herbicide resistance is a huge factor in the farming sector in Australia," he said.

"We are seeing resistance in harder to kill weeds like fleabane and feathertop Rhodes grass more often.

"We have a heavily glyphosate-dependent system in Australia, but the main thing I learned from the US trip is that even with these new herbicide tolerance traits, we can't afford to lose glyphosate out of our system.

"Learning from the US experience, we can be ahead of the game, not following in any footsteps."

Bernie said 80 percent of farms in the US are either leased or share-farmed on a short term basis, so most growers are farming in 'the now' not into the future, and this has compounded the resistance issue, particularly with their main problem weed Palmer amaranth.

Short term leases have led to practices such as not controlling weeds at all between cotton crops, allowing seeds banks to build, then coming in just prior to planting and spraying with hard chemistry, which then requires burning to rid the paddocks of weed trash.

"That's where we saw most of the issues," Bernie said.

"However the farmer-owned enterprises are run more like what you see here, they think long-term in their weed control, using similar strategies to those outlined in our Herbicide Resistance Management Strategy (HRMS).

"No matter what technology is coming in terms of these new traits, we still need Roundup (glyphosate) in the system, so it is wrong to look at these new traits as some sort of get out of jail free card.

"We don't want to lose glyphosate out of our system, so we need to use more laybys, residuals and rotation crops and stop seed set, by adhering to the HRMS and making sure our application methods are spot on, using the best nozzle technology available."

COTTON AUSTRALIA

Bernie Bierhoff presenting the learnings of the US weeds trip to the Cotton Australia General Meeting in November 2017.

In terms of the drift issue in the US, the tour participants found a lot could be attributed to growers using the wrong formulations of dicamba with higher volatility. The Walgett CGA members are no strangers to coping with unwanted drift, unfortunately.

This year the Walgett region has gained much attention after widespread phenoxy damage was reported in the area. However Bernie says every season he sees some level of drift damage on his farms.

"This whole stewardship factor must be done better and it's not just farm owners," he says.

"We need to make sure our operators are well trained, along with contractors and their operators, to be fully aware of how to manage herbicides correctly, and that includes monitoring weather conditions, boom height, speed and checking nozzles for example.

"Some problems with drift seem to be caused by people trying to get over a lot of country quickly, which leads to spraying in times of than less than optimal conditions, or poor application.

"In those cases we need to ask for help, from outside contractors or perhaps look at buying more machinery.

"We also need to make sure we don't become complacent when using spot spraying rigs with camera sensing, as they can still create drift under the wrong conditions, especially since herbicide rates for these machines can be higher.

"Anything will drift in the 'right' weather conditions.

"You could drift a bowling ball in the wrong conditions, so it's not just phenoxy (2,4-D) we should be focusing on. It wouldn't matter what you spray, glyphosate drift can still cause a lot of problems to conventional cotton, other crops and the environment.

"We really need to take a more serious approach to weed management on several fronts, as the future of our industry depends on correct stewardship of our chemicals and trait technology."

While some regions are suffering from herbicide drift events onto cotton, agronomist Barry Haskins says this season has been much better than last year throughout the Lachlan Valley.

Going the extra mile at Griffith

Based in Griffith, Barry's business employs a team of advisors, with their clients mainly in the Lachlan, where his company looks after a vast majority of the broadacre agronomy in the region. His business specialises in fee for service winter crop agronomy, however shares many cotton clients with other summer crop advisors.

This year's great record comes after a "bad season" last year (in the Murrumbidgee Irrigation Area and Lachlan), with widespread, varying levels of damage. Barry says the drift wasn't just affecting cotton. The region is home to grapes, citrus, almonds, walnuts and potatoes, all of which are susceptible to drift.

"There were different levels of damage, but no-one was unaffected last year," he said.

"While we have always taken the approach when recommending a herbicide to apply due diligence and give very strong guidelines for use, after last season we knew we needed to take some additional steps, which are working so far."

There are two weapons in Barry's arsenal against drift – knowledge from herbicide damage trials over the past 15 years, and producing spraying guidelines for his clients.

"We developed the guidelines for our growers last year and all have taken them on board," Barry says.

"It gives our clients assurance that they are doing what is essentially morally and legally right, by their neighbours, the environment and themselves.

"There is so much information out there, and we also have the technology in our nozzles, booms, weather information for growers, consultants and applicators that drift just shouldn't occur frequently."

Furthermore, his advisors work with clients to formulate a fallow spray plan, keeping in mind chemical choices during sensitive times for other crops. Barry also has other rules he applies.

"We don't recommend spraying phenoxy herbicides during sensitive times (predominantly at night).

"Our guideline is we don't spray phenoxy if the lights are on."

The second tool in Barry's arsenal to help build knowledge has been trial and extension work on the effects different herbicides have on cotton. This involved trialling different chemicals at different crop stages, which gave his agronomists a first-hand look at the propensity for damage and the types of damage caused by individual chemicals. Barry and his team have used this knowledge to better understand the herbicide drift risks and volatility risks to a cotton plant.

"We could then visually assess different types of damage and link it to the causes," Barry said.

Consultant Barry Haskins has taken a personal interest and approach to helping mitigate drift in the Lachlan and Murrumbidgee Irrigation Area.

"People need to be aware of that if they move to another herbicide as replacement to 2,4-D, we still have to be careful and remember that while 2,4-D gets a lot of attention, products like fluroxypyr (Starane) and MCPA are more volatile, and potentially much more risky.

"Inversions also get a lot of attention, but we've also got to be aware of the impact of poor nozzle, travel speed or boom height selection and other factors contribute to, or exacerbate drift.

"In December (2017) we only had two nights with no inversions.

"We were in a situation where we had to spray, yet we had minimal drift events because we avoided the critical time and used the right technology and application methods."

Barry outlines the three factors in creating drift if not managed correctly: conditions; application; and chemical.

"There is so much information out there to adhere to, there really is no excuse for these widespread drift events," he said

"We have got to stop drift because we are all farming in small communities and rely on these crops for our income.

"Additionally, we are all living in the same towns, with kids playing sport in the same teams, and we all need to get along.

"Unfortunately drift issues are dividing communities, and it's got to stop, and with some good guidelines, brains and effort we can make that happen."

Do good fences still make good neighbours?

It is said that good fences make good neighbours. If only life were that simple in the farming game… cotton growers in NSW certainly wished that was the case over the summer holidays, say Crop Consultants Australia.

Collaboratively, damage from a single spray drift incident on Christmas Day is estimated to have cost growers millions. The even more disturbing aspect to this story, particularly to those who are unaware of the phenonium that is spray drift, is the fact that the offending chemical is thought to have travelled over 70km before settling and doing its work. Sadly, this is not the only spray drift story for the 2018 crop. Reports have now been received in most of Australia's cotton growing valleys.

All of this is despite the best efforts in advertising, advocacy and information sharing by Cotton Australia, CRDC, CCA, CottonInfo, researchers and media. Why is this still a problem?

It may seem a little like preaching to the converted to be making comment on the impact of spray drift on cotton in a cotton magazine. The bigger picture, that we all need to keep in mind however is that spray drift does not only affect cotton, nor is it only 2, 4-D that will drift. Other crops, grazing land, communities, waterways and of course bees can all potentially be impacted by both on, and off target spraying, no matter what the active ingredient or purpose of the spray. Anyone in the farming game is responsibly ethically, financially and environmentally to ensure that they are adopting best practice in their planning and execution of spray application of all chemicals. This is an issue that has the potential to do major damage to reputation and 'social licence to operate' of all involved in Australian agriculture.

With more and more cotton being grown in traditional sorghum cropping areas, operators who may have been 'getting away' with less than best practice, and didn't consider that the spray drift message was relevant to them

With all of the science and understanding that we now have around inversions, and the brilliant online mapping tools available to us such as CottonMap and BeeConnected, how is that spray drift continues to make headlines? Is it apathy? Is it ignorance? Or, is it just a stubborn reluctance to accept the science and continue with age old routines of spraying at night and in the early morning when it was 'still and safe'? In the not so distant past, it would have been difficult to accept, let along prove, that spraying a field on Christmas day could impact a crop 70 km away. As long as your neighbours were happy, you had a safe and successful spray. This however, could be a big part of issue.

While it may seem to many of us that this is an old and tired issue, spray drift (particularly that related to cotton damage) is in fact an evolving and shifting one (pardon the pun). With more and more cotton being grown in traditional sorghum cropping areas, operators who may have been 'getting away' with less than best practice, and didn't consider that the spray drift message was relevant to them, are now finding themselves in hot water. Additionally, as our understanding of suitable spray conditions increases, operators are having to spray their required hectares within a much shorter safe window. For many who are still using older spray rig technology, this is simply not achievable and will require significant financial outlay to upgrade.

As an industry, we need to combine to continue to share the message of safe spray practices and ensure that it is not just cotton that we keep front of mind in this discussion. Constructive and positive discussions about best practice need to continue, particularly in public forums such as social media, to ensure the broader public is clear that the issue is being addressed in a proactive manner by industry.

The message is pretty clear;

1. Don't spray Group I herbicides at night (or early morning)
2. Don't use LVE in summer
3. Don't go 'off-label'

There is so much valuable information out there. Perhaps we still need to challenge some old thinking in order to get the message out to those who are just not listening, or just haven't had to listen in the past.

For more

www.cropconsultants.com.au
www.cottonmap.com.au
www.beeconnected.org.au

MELANIE JENSON

New tools in arsenal for drift management

Up until now, the only way to assess 2,4-D damage to cotton crops has been by visually inspecting it.

New research has shown crop sensing techniques can accurately predict not only yield impact but the dose of 2,4-D that has reached a drift-affected crop. CRDC PhD researcher Angelica Suarez Cadavid has found that crop sensing technology (hyperspectral, LiDAR and multispectral sensors) can be used to assess and map injury or damage to cotton caused by 2,4-D herbicide drift.

The results showed hyperspectral data can be used to predict yield loss with high accuracy as well as the dose that reached the crop (prediction accuracy of greater than 70 percent), regardless of the timing of exposure and dose. Angelica was also able to better understand the optimal window for assessing 2,4-D damage.

"It was possible to understand how the internal changes of the contaminated leaves, (photosynthesis, stomatal conductance and hormone contents) influenced their spectral response and lint quality.

"All of the internal variables analysed in this study have manifested a significant relationship with hyperspectral data and 2,4-D damage.

"On the other hand, the analysis of LiDAR-derived data supplied accurate information about the canopy height and canopy volume that could be strongly correlated with yield at different times of assessment, so these variables can be used as indicators of damage."

Experimentation with the LANDSAT 8 satellite imagery showed the traditional vegetation indices (VI) and individual multispectral bands could not predict yield in affected or unaffected areas of the crop. However by integrating all the multispectral bands Angelica could estimate yield of 2,4-D damaged areas, providing the degree and extent of the damage in the field.

"The technologies implemented in this study provided a range of reliable and accurate alternatives to traditional visual methods for damage assessment after spray drift," Angelica said.

"The procedures can be implemented as part of crop monitoring programs as some of the alternatives are easily available at no cost (satellite imagery), facilitating regular access to data."

These comprehensive analytical approaches also provided information on windows for optimal data collection after an incident. These methods indicate an optimal window between seven and 14 days, or more than 28 days after the exposure for the prediction of damage, however, as soon as two days after the cotton plant was exposed, hyperspectral measurements and LiDAR-derived data recorded significant differences in comparison with unaffected control plants.

"We also noted that care needs to be taken when defoliating, as defoliation in the affected area was not as successful as in the unaffected area, leaving most of the leaves on the plant (some still green)."

The research has proved that crop sensing techniques can accurately predict not only yield but the dose that reached the crop.

"The cotton industry, farmers, scientists and community in general have now options to choose among three accurate, non-destructive technologies," Angelica said.

"It is possible for all farmers to monitor crops during the season for potential exposure to the chemical.

"A drift monitoring program could equally benefit many other plant industries, as herbicide drift can affect large areas under different growing conditions and only a regional assessment can provide a real indication of the situation.

"The different technologies tested in this study can be incorporated to improve monitoring of cropping lands and the entire agricultural landscape."

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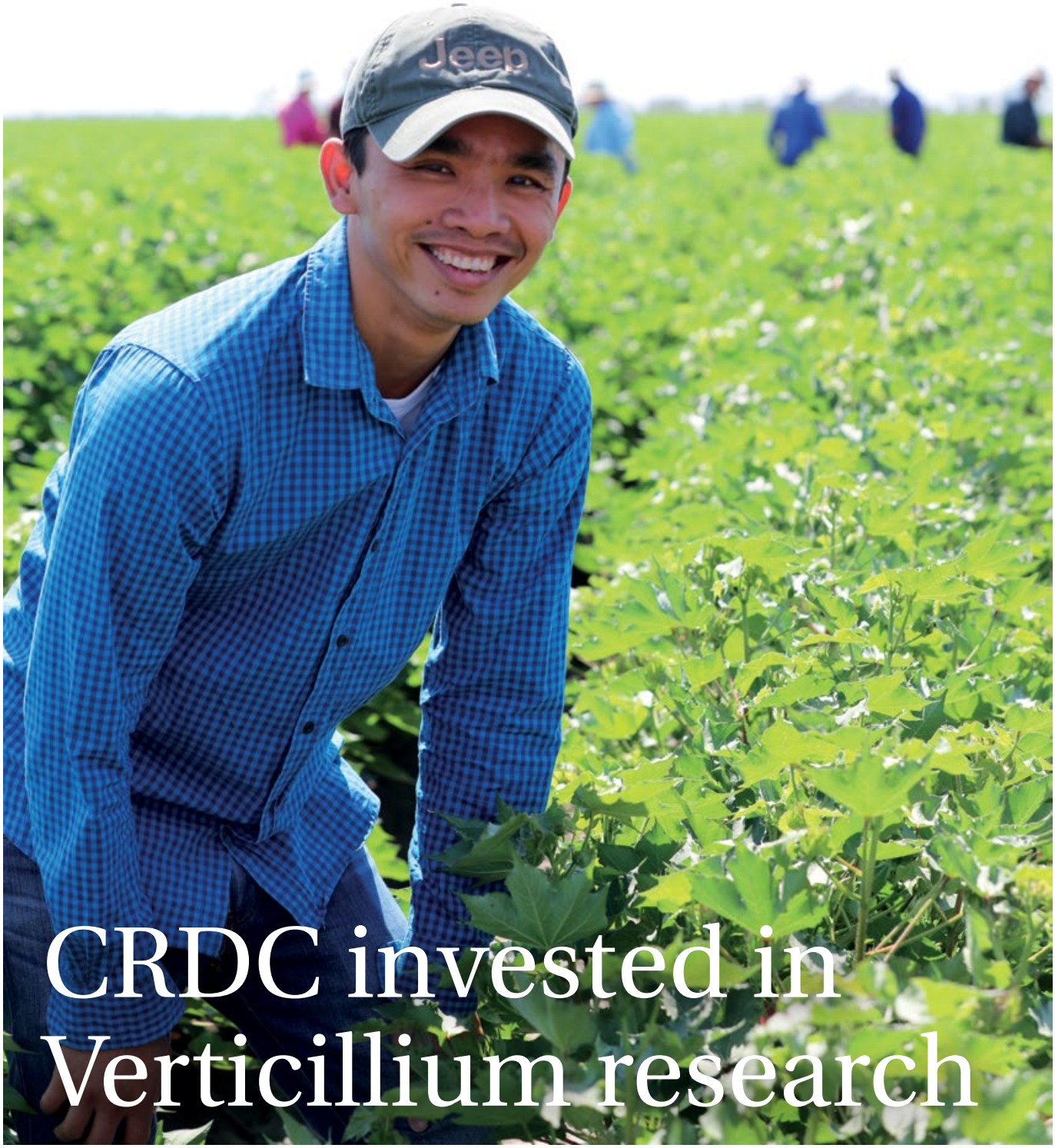

CRDC invested in Verticillium research

MELANIE JENSON

Verticillium wilt poses a significant challenge to the Australian cotton industry, with the 2016 CRDC Grower Survey indicating that 23 percent of farms were affected by Verticillium wilt with an average estimated yield reduction of 26 percent.

At a Verticillium field day in late January at 'Strathguyle' Mungindi, QDAF's Senior Research Scientist (Pathology) Linda Smith gave an overview of CRDC research underway.

"CRDC do hear the issues of growers and industry and are very supportive of Verticillium research – they want to solve this issue," Linda said. "They are proactively funding a range of projects looking at different aspects of managing and understanding Verticillium wilt."

Current funding for projects focussed on pathology for entire length of projects is nearly $5 million, including funding from grants, in-kind contributions and a cash component from CRDC of $1.5 million.

CRDC's portfolio of research into Verticillium wilt is extensive and includes:

- *Digital Technologies for Dynamic Management of Disease, Stress and Yield Program,* a project supported by funding from the Australian Government Department of Agriculture and Water Resources as part of its Rural R&D for Profit Program which includes the following cotton related components:

- Development of a molecular tool to quantify Verticillium inoculum levels in soils with NSW DPI's Dr Karen Kirkby and Dr Toni Chapman of EMAI.
- A new industry-wide disease survey, overseen by Dr Linda Smith, QDAF and Dr Duy Le, NSW DPI with CottonInfo Regional Extension Officers. This includes monitoring the incidence of Verticillium in all the cotton valleys. This project is also looking to understand disease suppressive soils. This component led by Dr Gupta Vadakattu, is aiming to determine what populations in the soil contribute to disease suppressiveness. For example: Is the fungus and bacteria found in the soil after different crops degrading the pathogen? Once you understand why a soil is suppressive, you can develop management strategies to support and encourage those types of fungi and bacteria in the soil.

- *Innovative solutions to cotton diseases* project led by Dr Duy Le.
- CottonInfo/QDAF Crop Rotational Trials with Dr Linda Smith, Dr Duy Le, and CottonInfo REOs.
- Supporting the CottonInfo Technical Lead, Disease and Biosecurity, Sharna Holman.
- Supporting Dr Linda Smith and Dr Karen Kirkby in overseas study and conferences.
- Honours Project with Aphrika Gregson, NSW DPI, to allow the Verticillium pathogen to be transformed to use visual indicators to determine alternative host.
- Biocontrol for noogoora burr through the *Control Tools and Technologies through Established Pest Animals and Weeds* program (with involvement from Graham Charles and Karen Kirkby, NSW DPI). The huge seed bank of noogoora burr is a source of inoculum and its thought that it has contributed to the high levels of verticillium in some cotton areas.
- Assessing if off the shelf drones can be used to identify Verticilium early in the season, research conducted by Jerome Leray from Western Aerial Mapping.

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Testing novel compounds

There are few active compounds to aide in the control of *Verticillium dahliae*, however under the new *Innovative Solutions to Diseases* project, NSW DPI's Dr Duy Le (pictured previous page) is leading investigations into potential solutions, with aims to commercialise potential products by assessing the efficacy of some novel and unregistered products in controlling major soil-borne pathogens in cotton.

Having initially conducted a review, *Disease-related constraints to Australian cotton production*, this project will now focus on looking at seed treatments with not-yet registered and novel compounds, and potential biocontrol agents for controlling cotton seedling disease that being black root rot in particular, biocontrol agents and bio-disinfestations of soil to suppress black root rot, Fusarium wilt and Vertcillium wilt and plant activators to induce resistance of cotton against Vertcillium wilt.

"We plan to look at a range of products, both commercially available options, as well as products that are still in the discovery phase," Duy explained.

"Of course while the project will focus on these three diseases, we are responsive to industry needs.

"Following recent reports of unusually severe Alternaria, we have been conducting research to isolate and identify the species of Alternaria involved and will be screening fungicides to determine best fit for industry for permits/registration."

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Dealing daily with Vert

Dealing with Verticillium wilt affects every day management decisions at 'Strathguyle', while finding a way to successfully manage the disease is now ongoing through several research trials on the farm.

The path to serious Verticillium infection was not a 'usual' one at 'Strathguyle'. Up until five seasons ago, the farm only grew conventional cotton, a rare sight in today's Bollgard landscape. Farm manager Andrew O'Connor has been at 'Strathguyle' long enough to see the decline of the Fusarium problem and the development and subsequent widespread effect of Verticillium.

"Prior to moving to Bollgard varieties we were growing conventional (Sicot 730) to help manage Fusarium, as we could pretty much go zero till and it helped our rotation program.

"During this time we had not seen Verticillium impact our fields, but little did we know we had been building up inoculum in the soil through our management practices.

"When we moved to Bollgard II, we got smashed by Vert."

Andrew said they found it was Verticillium around four seasons ago, after having plants tested. Since then, it's been "bad years for the disease".

"Dry winters meant no rotation crop, so we started to push higher nitrogen and shorter irrigation intervals which all combined to create the perfect storm," Andrew said.

"In the 2014-15 season, the crop looked great to peak flower, then just fell over as a result of Vert.

"Now we are still struggling to grow a five bale per acre crop (farm average) while the rest of the industry are growing six bales.

"It's disappointing when you can have a crop looks great, then after second irrigation large areas of it go down.

"I'd say last year and the year before we've had a yield penalty of 20 percent over the entire crop.

"Added to this, stress of any kind – heat, water, water logging, nitrogen or chemical stress – just makes that plant a bit more susceptible every time."

He's seen so much Verticillium, Andrew can now visually distinguish Verticillium from Fusarium.

"Vert presents differently to Fusarium, we tend to notice Fusarium earlier in the season and the vert around the second irrigation, around flowering," Andrew said.

"It also spreads in a different pattern through the field than Fusarium.

"Anywhere we've left a siphon going if we've got a few hot rows, a couple of weeks after you will see the Vert.

"Vert also has no pattern to it, affected plants can be across the field randomly, while Fusarium is not as mobile.

"We have had Fusarium for a long while and it has been quite stable and immobile in the patch it is in.

"We have a known Fusarium area in one field, we've had it there for the last 20 odd years, and with today's varieties with high F-Ranking, you won't even see it (Fusarium), but Vert catches it up."

The importance of staying away from legumes has also become blindingly obvious this season.

"We have seen a significant difference in the cotton crop where we had a two tonne to the acre wheat crop compared to where we had a one tonne chickpea crop," he says.

"We are seeing more Vert in the chickpea fields – and while we did okay with the chickpeas, we are feeling the impacts on the cotton now."

Andrew's advice for other growers, based on his experience starts with getting plants tested the moment any symptoms are seen.

"I think everyone's got it, just eventually the inoculum levels build till it starts to show in the plant," he says.

"For us, Verticillium management is an everyday response – in all our management we think about the effect on Vert.

"The problem with it is it almost flourishes in ideal conditions, and we are finding we can't capitalise when we do get a good season."

Andrew's advice to growers:

- Get suspect plants tested straight away
- Review Fusarium management techniques
- Huge part of management is farm hygiene – get rid of the weeds, especially Noogoora burr and peach vine
- Don't grow chickpeas
- Plant later
- Put first irrigation off as long as possible to keep soil temperature higher
- Keep soil above 26 degrees
- Cultivate less
- Incorporate fields immediately after picking

'Strathguyle' farm manager Andrew O'Connor has worked with CottonInfo Gwydir Valley REO Janelle Montgomery to establish many Verticillium trials on the farm after suffering severe impacts from the disease.

MELANIE JENSON

Solarisation under the microscope at Garah

QDAF Principal Research Scientist (Pathology) Dr Linda Smith, Senior Plant Pathologist Linda Scheikowski and Tim Shuey.

QDAF's Principal Research Scientist (Pathology) Dr Linda Smith has been trialing soil solarisation for *Verticillium dahliae* control in a project with CRDC.

With support from CRDC, Linda attended an international Verticillium conference in 2016, where she heard that in Spain, soil solarisation in cotton and olives was resulting in a significant reduction (undetectable levels or very low levels) of the pathogen to 40cm depth, after solarisation for four to six weeks when temperatures of 40+ degrees C were reached. Trials in Canada have also shown positive results, indicating that microsclerotia are killed following one to two hours exposure to 45 degrees.

"On learning this of course I was keen to trial solarisation in Australia," Linda said.

The experiment was set up among the many trials underway at 'Strathguyle' near Garah in North West NSW.

For this experiment, trial hills were covered with biodegradable plastic and left for around six weeks (the plastic degraded in five weeks). Soil samples taken at the start of the trial will determine the initial soil population of V. dahliae, while samples collected six weeks later will be used to compare the plastic vs no plastic plots to test for any reduction in inoculum levels. The next step is to test the plots when they go back to cotton, to assess disease incidence and progression, as well as yield.

Rotation trials continue

Linda is also overseeing crop rotation trials running now for two years across six sites, in an effort to ascertain which crops best decrease inoculum in the soil. It is already understood that legumes are hosts for Verticillium, and sorghum/cereals provide a better option. However this research is based on overseas experiences which Linda and her team are now testing under Australian conditions.

"When the fields go back into cotton (after rotation crop), we will be taking stem cuts, isolating the pathogen and setting up bio assays to look at virulence level," Linda said.

"You might have the same inoculum level but one isolate may cause less disease than another isolate because of its virulence capacity.

"This project has been going for two years and we are still analysing data."

Corn and sorghum on radar

In a separate CRDC trial at 'Getta Getta' near North Star, QDAF's Senior Plant Pathologist Linda Scheikowski is leading research to look at the effect rotation crops of corn, sorghum, cotton and fallow have on disease development.

Preliminary results indicate that rotating to corn and sorghum for one season is helping to reduce the Verticillium inoculum. Further assessments are being made this season to determine the effect two years of corn, sorghum or fallow have on disease levels compared to continuous cotton, with more disease already showing up in the continuous cotton treatments.

Top management strategies

1. Variety – choose varieties with the highest V-rank.
2. Incorporate cotton residues ASAP after picking to encourage rapid breakdown of plant material.
3. Crop rotation with non-hosts eg sorghum and cereals. Avoid legume rotations. Initiate rotation early before inoculum builds to high levels in the soil. Avoid back-to-back cotton.
4. Farm hygiene – control volunteer and ratoon cotton, noogoora burr and other alternative hosts. Leave Verticillium-affected fields to last in cycle operations, so as not to move pathogen between infected and non-infected fields.
5. Manage irrigations and tail water. Verticillium will move around the farm in tail water. Avoid overwatering and waterlogging which can increase disease incidence.
6. Manage nutrition and water to avoid late season growth as Verticillium is favoured by cooler temperatures, extending the period of growth late in the season increases the risk.

Going fluoro for research

CRDC-supported Honours student Aphrika Gregson has become an integral member of the pathology team and working with cutting edge technology to understand Verticillium wilt.

This work is aiming to identify and confirm *Verticillium dahliae* disease entry and infection pathways in cotton plants, by using a fluorescent protein that allows the pathogen to be seen in an infected cotton plant or host.

The green fluorescent protein (GFP) gene will show researchers if a plant is a host or Verticillium, the level of infection and the spread through the plant.

CRDC's Susan Maas said this exciting research is based on transformation with GFP of *Fusarium oxysporum* f.sp. *cubense* (Foc) at University of Queensland (UQ) to help the Australian banana industry in its fight against the devastating Panama 4 disease.

"We (CRDC) saw that the banana industry learned a lot about disease progression, including how the fungus moves through the plant and when and where it produces spores using this technique," she said.

"We felt that this was definitely something that could be used for Verticillium research and are really excited that Aphrika is collaborating with this UQ team."

Aphrika's Honours project has only just commenced, and will initially focus on adapting the technique to Verticillium dahlia, before applying the transformed strains to look at colonisation, virulence and host plants.

Further to her Honours research, Aphrika works with NSW DPI in a technical support capacity on two CRDC-supported projects.

Aphrika is working on the annual NSW cotton industry disease surveys, and provides a diagnostic service to industry for cotton diseases and disorders.

"Further to providing a snapshot of the state of disease across cotton fields, together with data from CRDC/QDAF disease surveys, we can develop a geospatial database of cotton pathology surveillance and best practice information," Aphrika said.

MELANIE JENSON

CRDC-supported Honours student Aphrika Gregson is adapting knowledge from the banana industry's fight against Panama 4 disease to research Verticillium wilt control.

This project is part of the *Digital Technologies for Dynamic Management of Disease, Stress and Yield Program* supported by the Australian Government's Rural R&D for Profit Program.

The young researcher is also part of the *Innovative solutions to Cotton Diseases* project, led by NSW DPI's Dr Duy Le. This project is focusing on key pathology issues and potential solutions. It is working to identify new and or novel disease control agents that could have application for disease management in cotton production systems.

"We hope through this project to help growers by finding new integrated disease management strategies for Verticillium wilt," Aphrika said.

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Diagnosis for decision making

NSW DPI Research Pathologist Dr Karen Kirkby is making headway in her work on the development of a molecular diagnostic tool to for growers or agronomists to quantify *Verticillium dahliae* inoculum levels in soil.

The aim is to develop a tool to identify levels of infection in the soil so fields with high levels if inoculum can be avoided and instead identify fields (pre-plant) for cotton which will have less risk of causing disease in the following season. Karen is working with Dr Toni Chapman, a molecular specialist at Elizabeth Macarthur Agricultural Institute to develop the tool. The research is a part of the *Digital Technologies for Dynamic Management of Disease, Stress and Yield Program,* a project supported by funding from the Australian Government Department of Agriculture and Water Resources as part of its Rural R&D for Profit Program.

"The tool will be similar to a fertiliser test," Karen said.

"You would send in a soil sample from a particular field and we would identify how many propagules per gram in that soil, which is representative of the entire field.

"The sampling strategy in cotton fields will be important as pathogens are spatially variable.

"We hope to differentiate strains, and the test will be quick, accurate and reliable.

"Currently, to determine pathogen levels we use a common technique called dilution plating, which is very hands on and time consuming and we don't get the answers very quickly, hence the need for this molecular tool."

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Opportunity for cotton in closed loop system

CRDC's Allan Williams talks man-made fibres and the future of micro-plastics in Taiwan.

In collaboration with the International Cotton Advisory Committee and the Taiwanese Ministry of Economic Affairs, the Taiwan Textile Federation organises a biennial seminar. The 2017 theme was 'Market Trends and Sustainability of Cotton and the Textile Industry', and I was invited to address the seminar on the topic of Australia's on-farm sustainability credentials.

Taiwan is a significant producer of man-made fibres (MMF), especially in the area of functional or high-tech fibres. In light of the rise and rise in market share of polyester, the increased emphasis on the sustainability of how all textiles are produced, and the increasing concerns regarding the impact of micro-fibre plastic pollution from textiles (see following article), the seminar provided the opportunity to highlight the on-going efforts to continually improve the sustainability of cotton farming, and to understand how the Taiwanese man-made fibre industry viewed the increased focus on micro-plastic pollution.

The seminar started with a range of presentations from fibre market analysts, who confirmed the increasing dominance of polyester: its growth in market share outstrips all other fibres combined. The total market share of polyester is now 50 percent, and as well as taking market share from cotton, it is also taking it from other MMF such as nylon. However, one MMF that is also increasing its market share is cellulosic fibres (rayon, viscose), and this fibre class is likely to be an on-going threat to cotton.

The reasons behind the continual rise in market share of polyester include its price, and especially its multi-functionality, that is, the ability to add technical innovations to the fibre, critical in a market always interested in the latest 'new thing'. An on-going challenge for cotton is adding functionality to its performance, and this is an area that CRDC will continue to invest in, along-side like-minded partners.

One of the critical 'functionalities' for all textiles will be the ability to recycle them, as part of a trend to 'closed-loop' systems. This presents both an opportunity and a threat for cotton; one of the advantages of polyester is its durability and thus recyclability, and the ability to recycle PET drinking bottles into polyester yarn was mentioned by several speakers during the seminar.

However, this durability, when present in the environment, makes polyester a very persistent

ABOVE: CRDC's Allan Williams was invited by the Taiwan Textile Federation to speak about Australia's on-farm sustainability credentials at its biennial seminar.

pollutant – especially in the form of micro-fibres. Cotton's bio-degradability may be an advantage – to date the research looking at micro-fibre pollution from textiles has not found any evidence of cotton micro-fibres.

There is an increased regulatory focus on micro-plastics pollution from all sources, including micro-fibres from synthetic clothing, and while there may be the opportunity to emphasise the biodegradability of cotton as a good reason to use more cotton, the MMF industry will no doubt respond by focusing on its recyclability. Cotton is very difficult to recycle into an equally valuable product, and the new CRDC Strategic Plan will investigate the opportunities for adding value to cotton through high-value recycled uses.

Avoiding micro-plastic fibre pollution

Increasing use of natural fibres for clothing could be a way to stem the flow of micro-plastics into the environment.

An extensive literature review has uncovered estimates suggesting that 20 to 35 percent of micro-plastics in the marine environment are plastic micro-fibres from synthetic clothing. As well as micro-fibres from textiles, other sources of micro-plastic pollution include cosmetics, the breakdown and fragmentation of plastic rubbish such as bags and containers, and car and truck tyres.

Commissioned by CRDC and Australian Wool Innovation, the review aimed to give an overview of the current state of knowledge around micro-plastic pollution, with a focus on micro-fibres from textiles – more than 60 percent of global textiles are now produced from synthetic fibres. The review suggests the most effective strategy for consumers to reduce their contribution to micro-fibre pollution would be to choose garments made from natural fibres which are biodegradable and do not contribute to the build-up of plastic micro-fibres in the environment.

Real impact becoming clearer

Micro-plastic pollution of marine and freshwater environments has been identified as of concern for about two decades, but there is now significant evidence of the negative impacts on aquatic habitats and marine organisms, though less is known about impact on human health.

While research is only beginning to provide any clarity on the potential for humans to be exposed to physical, chemical or biological risks from micro-plastics in the environment, concern is growing as evidence for exposure increases. There are three main mechanisms for impacts on human health:

- Micro-plastics may enter the human body through the food chain and drinking water with a small proportion thought to be retained in the body. As for other organisms, textile micro-fibres may pose a higher risk than other particles due to their shape;
- The high relative surface area of micro-fibres and its hydrophobic nature facilitates adsorption of chemicals from surrounding water, raising the risks of human exposure to these compounds when consuming seafood;
- Biological risks occur when micro-plastics host bacteria, including some linked with human gastrointestinal infections.

The report reviews the current understanding of the extent of pollution due to micro-fibres from textiles, and its impacts.

The report provides advice on possible strategies to reduce pollution of micro-fibres in three categories:

1. Reducing production and consumption of clothing
2. Improving consumer practices in the use phase of synthetic garments
3. Replace use of synthetic fibres with natural fibres.

Of these, the report notes that last point is likely to have largest effect.

Shoreline tells story

From a textile perspective, key findings include that globally, the proportions of different plastic fibres found in shoreline habitats that received sewage were found to resemble those used in clothing, that is, about 67 percent polyester, and that waste water treatment sludge contained mostly fibres of polyester (78 percent) and acrylic (22 percent). Further evidence for the deposition of micro-fibres from clothing polluting deep ocean sediments comes from analyses reported in 2014, where micro-plastic fibres were up to four orders of magnitude more abundant per unit volume in deep-sea sediments from the Atlantic Ocean, Mediterranean Sea and Indian Ocean than in contaminated sea-surface waters.

As it is forecast that production of synthetic textiles will continue to increase as global population rises to over nine billion by 2050, with the contribution of synthetic textiles also expected to grow in a society that has rapidly adopted cheaper 'fast fashion', it is likely there will be an increasing regulatory focus on reducing the negative impacts of the synthetic fibre industry.

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Electricity or diesel: Which is best for you?

Considering a pump upgrade? Not sure whether to go electric or diesel? CottonInfo's Jon Welsh and AgEcon's Janine Powell say there is much to consider.

As ageing pump infrastructure comes to the end of a 20 to 30 year working life, some irrigators fortunate enough to have the option of continuing on with grid connection are now actively considering switching to diesel. This investment requires some awareness of government policy influencing energy prices, as energy policy incentives to build renewable infrastructure, emissions targets, maintaining consistent supply and affordability are likely to be key issues for growers to consider when looking to upgrade.

Energy cost the key driver in the long term

Pump stations are a long-term, significant investment, and not only have they become expensive to operate, get it wrong and you put your crop at risk. Areas to consider when investing into a pump station include the capital costs, maintenance and energy costs. Figure 1 illustrates the weighting and key considerations for each category with the majority of costs accrued in energy through the project life.

The chart illustrates the importance of making good decisions on the capital (five percent) and maintenance costs (10 percent) which in turn influence energy costs – which are the bulk of lifetime costs. As well as system design and efficiency influencing quantity of energy used, the longer-term pricing of energy sources is largely unknown and influenced by global markets and government regulation.

Electricity as an energy source

Electric pumps have a reduced labour requirement for servicing and maintenance when compared with diesel systems. However, electric pumps face significantly higher costs where infrastructure is not in place – often the application to connect and connection costs will make the investment prohibitive. Some advantages of electric pumps include:

- Electric pumps are more efficient (50 to 85 percent) than diesel pumps (20 to 35 percent);
- Electric pumps integrate more easily into automation functions;
- Solar can be integrated into a grid connected pump relatively easily. New regulation to solar feed-in-tariffs means that in some cases the excess power fed into the grid can also offset the installation costs when the pump site is unable to use the solar generation.

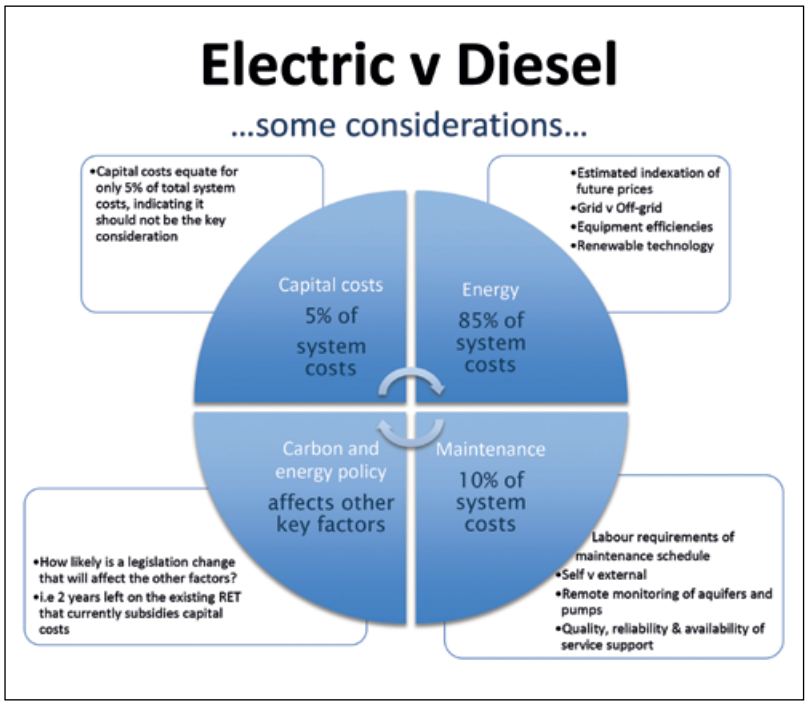


Figure 1: The lifetime cost of an irrigation system (Source: McMullin 2016).

Electricity pricing has become a major issue for irrigators with well-documented price increases flowing on to higher per megalitre pumping costs. A recent report by the Australian Energy Market Commission (AEMC 2017) shows the 10 percent increase in power prices this year was due to higher wholesale electricity costs, driven by the retirement of ageing coal fired power stations and increasing gas prices. Electricity costs consist of three separate categories – each inter-related to government policy;

- Wholesale electricity purchase costs: these costs

include purchases from the spot energy market and financial contracts, ancillary services, market fees and energy losses from transmission and distribution networks;

- Regulated network costs: these costs comprise approximately half of the cost of the electricity invoice. The distribution costs are determined by the Australian Competition Tribunal based on previous and forecast revenues and costs;
- Environmental policy costs: federal and state government policy initiatives such as the nation Renewable Energy Target and Climate Change Fund flow through to these costs.

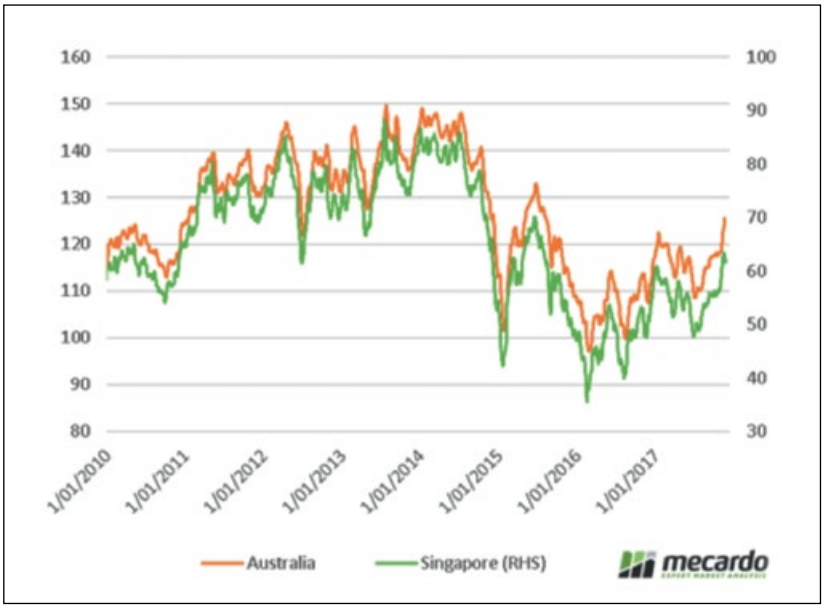
Modelling an investment scenario for a grid-connected irrigation pump upgrade is complex given the dynamic nature of policy settings. With Australia's emissions reduction obligation under the Paris Agreement, it is likely that electricity users will continue to bear the financial cost of a transition to a lower carbon economy.

Although the December 2017 AEMC report shows a more stable future trend to regulated network costs, wholesale energy commodities such as coal and gas are subject to global markets and exchange rates which are largely unknown. Environmental policy costs are also expected to increase at an average annual rate of more than 16 percent to 2019-20. At least by incorporating solar into a grid connected pumping scenario (or domestic application) these environmental policy costs can be off-set by accessing Renewable Energy Certificates credited to the capital costs of the purchase.

Diesel prices as an energy source

Diesel pumps become more cost competitive (in terms of maintenance costs) as the size of the pump increases – fuel efficiency increases as engine horsepower increases. The largest fixed costs associated with diesel systems are depreciation. Variable costs for pump servicing requirements are proportionally the same for small and large diesel pumps. Irrigators may potentially be exposed to fluctuations in the world crude oil price, exchange rates and the unlikely removal of the diesel fuel rebate.

Figure 2: Australia and Singapore petrol price.



With recent reports forecasting diesel prices to move off their long-term lows and future price rises to exceed inflation, it is helpful to understand how exposed cotton is to these price increases.

According to the CRDC-supported 2017 Australian Cotton Comparative Analysis compiled by Boyce Chartered Accountants, per hectare growing costs increased last season, in what is a consistent upward trend for Australian cotton growers. Given diesel prices during this period were historically low in present value terms, and assuming revenue remains constant, any input price increase is likely to erode gross margins. With recent reports forecasting diesel prices to move off their long-term lows and future price rises to exceed inflation, it is helpful to understand how exposed cotton is to these price increases.

A survey of four international energy research agencies has revealed the growing demand for liquid fuels in populous Asian economies could result in the real price of oil increasing by between two and four per cent per year (over and above inflation) to 2040. With reduced oil refining capacity, Australia's economy is almost entirely reliant on imported liquid petroleum products to power agricultural farm equipment.

In the recently released CottonInfo 2017-18 *Cotton gross margin series*, undertaken by Jon and Janine, the contribution of diesel fuel to the cost of field operations and irrigation was assessed. The gross margin budgets were analysed to better understand risk exposure and sensitivity to price fluctuations for energy inputs such as diesel.

Looking at diesel use for irrigation in the furrow irrigated budget, priced at $0.75/L farm (net of taxes) and assuming the water is lifted twice from a river, $19 of the $50/ML is attributed to diesel use (the other costs are fees $17/ML and maintenance $14/ML). This analysis showed that for furrow gross margins, 90 percent of results fall in the range of $2447 – $2649, and overheads $2107 – $2462.

The more energy consumed on farm, the higher the exposure to price increases. In CottonInfo's 2018 Gross Margin Analysis, total irrigation costs account for 15 percent of variable costs for furrow

MELANIE JENSON

Looking to replace an electric lift pump at Auscott Namoi requires some basic considerations, says Bill Back (pictured here with Jon Welsh and Janine Powell). "The axial flow lift pump is only used during irrigation, so doesn't warrant solar. At this stage we are looking to go diesel due to consistency of power supply and reliability. It's also easier to get support for diesel pumps, and we can't afford much down time in the middle of irrigating. I need capacity but not for long periods. Capital costs are always a factor, but for us in this instance it's about reliability and ease of maintenance."

irrigation and 20 percent in overhead irrigation. When the price of diesel is doubled (close to those prices experienced mid-2008), the furrow irrigated gross margin is reduced by 10 percent and the overhead irrigated gross margin is reduced by 18 percent. Energy-intensive bores powered by diesel are even further exposed to pricing.

As Australia's diesel is predominantly imported, the key factors influencing the farm gate price we pay are the $AUD exchange rate and the international market pricing based on international supply and demand. The chart compiled by *MECARDO* indicates an upward trend in nominal fuel prices since 2016 (figure 2).

For some growers, investment in an alternative energy solution can mitigate exposure to increasing energy costs and alleviate the effect on the bottom line. Cotton growers such as Narromine grower Andrew Gill have reduced irrigation costs by offsetting diesel use with solar energy, and many already have, or are following suit. The installation of a solar diesel hybrid irrigation bore pump on

Furrow Irrigated GM

Diesel price (net)	$0.75/L*	$1.00/L	$1.25/L	$1.50/L
Pumping costs $/ML	19	26	32	38
Gross Margin $/ML	2,676	2,593	2,500	2,419

Overhead Irrigated GM

Diesel price (net)	$0.75/L*	$1.00/L	$1.25/L	1.50/L
Pumping costs $/ML	57	76	95	114
Gross Margin $/ML	2,510	2,357	2,202	2,050

*Published GM

Andrew's farm has led to big cuts in fuel costs, greater irrigation efficiencies and a massive reduction in greenhouse gas emissions. Pumping costs have gone from $76/ML to $41/ML and he has slashed diesel use by between 45,000 and 55,000 litres a year. Over 25 years, that equates to a saving of more than one million litres of fuel and a reduction of more than 3000 tonnes in carbon emissions. A CottonInfo case study of Andrew's experience is available on the CottonInfo website.

For more:
www.cottoninfo.com.au/energy-use-efficiency

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