Spotlight.

ON COTTON R&D

Summer 2016-17

IPM: ensuring a viable future

New capacity to tackle disease

The power of people

Australian Government

Cotton Research and Development Corporation

Bruce Finney

In the Spotlight

Best wishes to all for the 2016-17 cotton season after a remarkable (as well as challenging) change in seasonal conditions.

Also a special welcome to the 80 or so new growers and dryland farmers returning to cotton. CRDC and CottonInfo are here to provide research, development and extension support to you.

Spotlight is one of a number of ways we share information and results from research. The CRDC, CottonInfo and *my*BMP websites provide access to the results of 25-years of cotton research and resulting best practices, plus contact details for Regional Extension Officers, Technical Specialists and the *my*BMP support team. If you would like to follow-up on any matters with CRDC please feel welcome to contact us directly.

After so much spring rain, this season is shaping up to be one of high pest pressure. This means that integrated pest management (IPM) has never been more important. As this edition goes to print, a series of CottonInfo IPM workshops, supported by CRDC, are happening across the valleys, so we have included the latest CRDC research results which highlight the need to practice sound IPM. What happens on each farm will affect other farms, now and into the future. So we urge growers and consultants to make sure your pest management is consistent with the IPM guidelines, the Insecticide Resistance Management Strategy (IRMS) and the Resistance Management Plan (RMP).

In response to grower feedback CRDC has doubled its R&D investment in disease management solutions and placed a particular focus on *Verticillium dahliae*. In this edition we have included a report on potential new management solutions by CRDC-supported industry pathologists who attended a recent international Verticillium symposium and are also working with growers affected by the disease in on-farm trials. More broadly, we have redefined how the annual disease surveys and pathology services will work to leverage greater benefit for growers.

While insect pests and disease pose great risks to industry, so does the increasing list of weeds which are becoming herbicide resistant. In a bid to move away from a reliance on chemical weed control, CRDC is investing in robotic and alternative methods of control. In this edition we also share the main messages from recent weeds workshops, which, like the IPM workshops, were designed to give growers and consultants the knowledge and tools they need to make decisions specific to their situation.

Luck is where preparation meets opportunity. CRDC's commitment to building human capacity is all about supporting preparation and enabling opportunities so the industry can be lucky! From supporting women in the Rural Women's Award, through to improving and updating knowledge at the IPM and weeds workshops, sending researchers to international events, and supporting programs for emerging leaders and industry newcomers, the importance of developing people runs throughout. We hope you enjoy reading about the people who are receiving support from CRDC and our partners. Support can change lives and secure our industry into the future.

Lastly, we share with you a summary of CRDC's investment and achievements in the last financial year. We are proud of our results, reached with our partners, in serving the Australia cotton industry and community.

Bruce Finney
CRDC Executive Director

Summer 2016-17

Features

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

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Want to see more of Spotlight?

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

Included with this edition is the **2017 CottonInfo cotton calendar,** featuring a range of cotton faces: cotton growers, researchers and members of the CottonInfo team. Additional copies of the calendar are available on request by emailing spotlight@crdc.com.au

Cotton News

Fast Facts

$11.3 million

Dollars in direct government funding will be managed by CRDC under three Rural R&D for Profit programme projects (Page 5)

100

Percent of two-spotted mite strains tested contained individuals resistant to bifenthrin in 2014-15 surveys (Page 10)

0

The number of products registered for the control of mealybugs (Page 13)

400

Tonnes of carbon per hectare can be stored in riparian river red gum forests, with 40 percent of this carbon stored in the soil (Page 24)

Sally Dickinson, Yvonne Chang, Hollie Gall, Fleur Anderson, Sophie Hansen, Kalyn Fletcher, Di Purcell, Ruth Redfern and Liz Alexander at the RIRDC Rural Women's Award celebration.

Supporting rural women

CRDC HOSTED a group of cotton industry leaders at the RIRDC Rural Women's Award dinner in Canberra in September.
Dianne Purcell and Ruth Redfern of CRDC were joined by CRDC director Liz Alexander, Cotton Australia director Fleur Anderson, Wincott's Sally Dickinson and Hollie Gall, and Yvonne Chang, the CRDC-supported winner of the 2016 ABARES Science and Innovation Award.

CRDC has long been a supporter of projects and initiatives designed to support rural women, such as the RIRDC Rural Women's Award and Wincott.

"We support a wide range of programs that help to develop our industry's people – from Horizon Scholars and Future Cotton Leaders to the ABARES Science and Innovation Awards and RIRDC's Rural Women's Award," CRDC Executive Director Bruce Finney said.

"These programs are part of a suite of initiatives that we invest in as part of our 'people' program – and we're always looking for outstanding emerging and established leaders to participate in these programs," Bruce said.

"Developing leadership, like that shown by the Rural Women's Award finalists, is a key focus for the cotton industry, and we're pleased to be able to play our part."

The 2016 national recipient of the RIRDC Rural Women's Award was Sophie Hansen, a food and farming blogger from Orange, NSW. Sophie will use her bursary to develop an innovative, self-paced online social media course for Australian farmers and farming communities, helping them to tell their stories. The runner up was Kalyn Fletcher, a seed producer from Kununurra in WA, who will use her bursary to investigate wet season cropping options.

"Opportunities to network with, be inspired by, and develop into such leaders are invaluable, which is why CRDC continues to support the RIRDC award, and many other programs which focus on developing the capacity of people in our industry," Bruce said.

For more
www.rirdc.gov.au/rural-women's-award
www.crdc.com.au

Familiar face at the helm

RICHARD Haire was announced as the new CRDC chair by the Minister for Agriculture and Water Resources Barnaby Joyce in September, replacing outgoing chair Dr Mary Corbett.

Richard is a well-known member of the Australian cotton industry, having held many leadership positions within the industry. He is also a former CRDC director, having served on the board from 2011 to 2014. Most recently, Richard was Managing Director and Regional Head of Olam International, and the former CEO of Queensland Cotton.

CRDC Executive Director Bruce Finney welcomed Richard back to the board and into the chairperson's role.

"We look forward to working closely with Richard on our strategic investment in cotton RD&E to improve the profitability and productivity of growers and the industry," Bruce said.

In his announcement, Barnaby Joyce highlighted the wealth of knowledge Richard brings back to CRDC.

"I welcome Richard's leadership in this role to ensure targeted and intelligent investment in cotton RD&E continues to support a profitable, competitive and sustainable industry," he said, also thanking outgoing chair Dr Mary Corbett, who served as a director from 2008, and as chair from 2013.

Bruce Finney also paid tribute to Mary for her contribution to CRDC.

"Mary has provided sound and strategic leadership to CRDC and the cotton industry during her three years as chair and eight years on the board.

"On behalf of the board and CRDC, I thank her for her wise counsel and her lasting contribution to Australian cotton."

A word from the outgoing Chair

"I HAVE been reflecting upon my last eight years as a proud Board member and Chair of CRDC and what an incredible organisation and industry in which to work.

As I think about the cotton industry the words that spring to mind include collaborative, cohesive, enthusiastic, and innovative – and these are not just my words, but also the words I hear often from other industries when talking about cotton. Given the challenging environment of climate change, global competition, water and other environmental pressures, increased regulation and to cap it off, a significant shortfall of human resources, this is surely a mark of the industry's culture and resilience.

It has been a pleasure and privilege to serve the industry through CRDC and to watch the organisation grow and develop to meet changing R&D needs. For a small organisation with limited resources, CRDC certainly 'punches above its weight'. Notable recent achievements have included the success in securing over $11 million in additional funding from the Rural R&D for Profit programme; the co-creation with Cotton Australia of the first ever Sustainability Report; and the establishment of a national facility for cotton climate change research at Narrabri.

As I 'pass the baton' to Richard Haire, the incoming Chair, I'm delighted the organisation is well on the way to achieving the ambitious goals set out in the 2013–2018 Strategic Plan and I have every confidence that our vision of a 'globally competitive and responsible cotton industry' is well within our grasp."

– Mary Corbett

Nuffield scholar's people focus

Wee Waa cotton grower Daniel Kahl is cotton's next Nuffield scholar.

THROUGH his scholarship, supported by CRDC and Cotton Australia, Daniel will investigate where the next generation of farm managers will come from, and how quality candidates can be attracted to a career in farming.

Daniel is employed as the business manager of the Kahl family's company, Merced Farming, which covers 7500 hectares, 3500 hectares of which is developed for irrigation. In a full production year, the company produces 20,000 bales of cotton in addition to other rotation crops.

Having returned to the farm in 2014, Daniel is concerned about a lack of available skilled managers.

"We can readily access labour to operate machinery and carry out cropping activities. But it is the roles at middle management level such as farm supervisors, those who can manage a team of plant operators or irrigation across a whole farm, that we struggle to fill," Daniel said.

Daniel Kahl – 'it is only with a good team in place that full production can be a reality'.

"The challenge of attracting skilled labour is present across the wider agricultural industry. Is the answer to develop staff and help them to acquire the necessary skills to step-up and fill that role? Or is it to provide a more attractive opportunity to those who have gone away to further education and encourage them to return?"

This is a real and imminent challenge for Merced Farming. Having recently doubled in size through the purchase of additional property, the business is currently in a consolidation phase.

"We are readying ourselves and our team for when full production is upon us. It is only with a good team in place that full production can be a reality," Daniel said.

Daniel plans to travel to Europe, North America and New Zealand and study the human resources practises of corporate and family farming practices as well as what programs may be in place at an industry level to develop a skilled agricultural workforce.

Daniel's focus on workforce capacity is timely, given CRDC and Cotton Australia's collaboration on the industry's first Workforce Development Strategy, which was launched at the Cotton Conference in August.

For more
w www.nuffield.com.au

Leading cross-industry collaboration

CRDC is leading three major research projects announced over the past 12 months under the Australian Government's Rural Research and Development (R&D) for Profit programme.

This will see CRDC responsible for $11.3 million in direct government funding, coupled with a further $8.355 million from CRDC and research partners and $9.95 million in-kind support.

For the first time, one of these projects *Accelerating Precision Agriculture to Decision Agriculture,* announced in 2016, involves all 15 of the Research and Development Corporations (RDCs), of which CRDC is one. Led by CRDC, the project will design a solution for the use of big data in agriculture – increasing the profitability of producers, providing clarity about data ownership and access rights, and improving farming strategies.

CRDC is also leading the newly-announced *More profit from nitrogen: enhancing the nutrient use efficiency of intensive cropping and pasture systems* project. This project will improve the nitrogen use efficiency for the cotton, dairy, sugar and horticulture industries. Farmers will gain a better understanding of the various influences on nitrogen use efficiency, and improved confidence to adopt fertiliser management practices tailored to specific crop requirements allowing greater farm productivity and profitability.

The *Smarter Irrigation for Profit* project, also led by CRDC, aims to improve the profit of 3000 cotton, dairy, rice and sugar irrigators, with the support of 16 research and development partners and 19 farmer irrigation technology learning sites. Underway since 2015, this project has so far focussed on developing and extending autonomous irrigation capabilities.

CRDC is also a partner in five other projects under the two Rural R&D for Profit programme rounds thus far (outlined below) and is working with fellow RDCs on round three research projects.

- *Stimulating private sector extension in Australian agriculture to increase returns from R&D*, led by Dairy Australia;
- *Improved use of seasonal forecasting to increase farmer profitability*, led by RIRDC;
- *A profitable future for Australian agriculture: Biorefineries for higher-value animal feeds, chemicals, and fuels*, led by Sugar Research Australia; and
- *Consolidating targeted and practical extension services for Australian Farmers and Fishers,* led by RIRDC; and
- *Digital technologies for more dynamic management of disease, stress and yield,* led by AGWA.

These projects are just part of CRDC's collaborative research projects, with some 25 percent of all CRDC investments going to cross-sectoral R&D, including, for example, with the grains sector. CRDC is partnering with GRDC on issues such as herbicide resistance, weed sensing technology, nitrogen use and robotics, including a collaboration with GRDC's Future Farm program.

For more
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CRDC's Research Priority Forums are proving to be a successful method for establishing R&D priorities for new investments.

Setting research priorities

The forum in May this year, set the direction of research in 2017-18 under each investment program as outlined in the CRDC 2013-18 R&D Strategic Plan. These programs are farmers; industry; customers; people; and performance. In the last edition of *Spotlight* we outlined outcomes from the forum around the farmers and industry programs. In this edition we focus on the customers and people programs. Under each program, 'themes' and priority issues were ranked by the 78 forum participants, who included 55 growers and Cotton Australia representatives. Grower representatives from every CGA across the industry identify the R&D priorities that are most relevant to the growers they represent. In the most recent grower practices survey 80 percent of growers identified that their input to R&D through the CRDC comes via the Cotton Grower Associations (CGAs) or via the Cotton Australia R&D advisory panels.

CRDC General Manager R&D Investment Ian Taylor said the meeting provided relevant feedback and established a clear set of priorities for each investment program.

"It is vitally important to the CRDC that the R&D that we invest in on behalf of industry is meeting the needs of growers.

"This forum provides us with the knowledge to prioritise research and set a clear direction for 2017-18, and allows us to identify any gaps or issues which may need immediate attention and it is pleasing for CRDC to see that research is already underway for some priorities outlined in the discussions.

"We have bought forward R&D investment to 2016-17 in critical areas such as integrated disease management, and managing spray drift in the farmers and industry programs and in the customers program, the issue of preserving colour.

"In the people program we have moved to extend knowledge around integrated pest management and develop post-doctoral fellowships relating to digital agriculture."

Program: Customers

Preserving colour

The issue of preserving colour grade received the highest number of priority votes in the customers forum.

CRDC Customers R&D Manager Allan Williams says to expedite investigations, additional resources have been allocated to the existing work led by

CSIRO

CSIRO's Dr Lewis Wilson investigating the impact and management of honey dew from silver leaf whitefly (SLW).

CRDC's focus on SLW has been expanded and placed into a dedicated project being led by Dr Simone Heimoana.

The focus on SLW has been expanded and placed into a dedicated project being led by Dr Simone Heimoana titled *Investigating the relative contributions of weathering, insect honeydew and fungal agents to cotton colour grade changes and discounts*.

"This new project includes investigating management options to minimise the effects of wet and cloudy weather on colour grade, and the identification and testing of novel approaches to avoid or minimise the impact of wet/cloudy weather and sooty mould," Allan said.

Man-made fibres

The challenge of competing with man-made fibres

MELANIE JENSON

CRDC supports many programs to expose young people to the cotton industry, including supporting students from Farrer Agricultural College to attend the Australian Cotton Conference.

(MMF) also received a lot of attention during the forum. There are a number of fronts to cover through R&D in the competition with MMF, including:

- Functionality – what are the advantages of cotton over MMF, and how can the performance of cotton be 'improved' from a textile perspective to better compete with MMF?
- Environmental 'performance' of the raw materials – what are the relative advantages and disadvantages from an environmental perspective of producing the raw materials?
- Environmental impacts of processing the different raw materials – how can the efficiency and environmental impacts of processing cotton be improved without affecting its performance?

Program: People

Theme: Workforce capacity

CRDC's people program R&D Manager Dr Ian Taylor says an industry is its people. As such CRDC has always been committed support of increasing the human resources and capacity of individuals along with long-term projects to understand our workforce, our future workforce needs, and what it takes to retain a capable workforce.

"CRDC has a range of programs and initiatives which support growers/crop managers, researchers and young people/future leaders involved at all levels of industry.

"The forums highlighted several areas where capacity or knowledge could be extended and improved."

Building workforce management practices

Integrated pest management (IPM) is the method the cotton industry has developed to manages pests on farm. Adherence to IPM reduces the risk of resistance to insecticides and Bt technology, however there is growing concern that use of these principles has not been as stringent as it could be. As a result CRDC has supported an extensive roll out of IPM workshops with CottonInfo across five regions in November and December this year. New material and information for crop managers has been created to raise the level of awareness around resistance and IPM.

Digital agriculture

As we move in the era of digital agriculture, it is necessary for RD&E to work toward the preparedness of crop managers, whether consultant or grower, to activate and use the functionality of digital agriculture.

"Two post-doc proposals (decision making in complex systems; and skill sets required for future digital farming systems) are being developed to address this issue of preparedness," Ian said.

"We are also leading the collaborative *Accelerating Precision Agriculture to Decision Agriculture* project under the Rural R&D for Profit programme, which will design a solution for the use of big data in agriculture."

Knowledge transfer and capacity building for new entrants

The forum also saw calls for the support of the Field to Fabric course for new growers, researchers and human resources (HR) staff. This course was supported by CRDC until 2014. CRDC has requested a full research proposal which will be reviewed by the panels and will then require CRDC Board approval.

For more on our current investments, download the list of CRDC R&D investments 2016-17 - www.crdc.com.au/publications/crdc-rd-investments

Keep IPM on your agenda

While Bollgard 3 offers additional resilience against *Helicoverpa spp.* with the inclusion of the Vip3A gene, there are growing risks of widespread insecticide resistance forming in many other pest species if the principles of integrated pest management are ignored.

Researchers have recently detected rising levels of insecticide resistance in silverleaf whitefly (*Bemsia tobacci*) to a cornerstone product. Resistance in mites is present and sucking pests such as mirids could be next.

"The cotton industry must continue to strive for a strong integrated pest management (IPM) system to support Bollgard 3," says CSIRO's Dr Lewis Wilson.

"If we drift into increased use of sprays in the belief that this is keeping retention high and pushing up yield then we risk the future that has happened in the United States' Mississippi Delta.

"Growers there are now spraying more in Bt cotton than they were in conventional cotton.

"This is due to resistance to insecticides in *Lygus*, emerging Bt resistance in *Helicoverpa* and increasing secondary pest problems (mites) as a result of increased spraying.

"We don't want to end up there, so we need to realise that while Bollgard 3 is a great platform for IPM, it also benefits from the support of a strong IPM system."

"Growers in the Mississippi Delta are now spraying more in Bt cotton than they were in conventional cotton."

Monitoring shows trends

In Australia, CRDC's annual insecticide monitoring programs have detected increasing resistance to key products in silverleaf whitefly (SLW) and mites. Both are species that flare easily and require careful IPM to manage effectively.

Insecticide resistance monitoring is an essential component of the cotton industry's Insect Resistance Management Strategy (IRMS) with results of the program used to ensure the IRMS remains effective and relevant to the country's dynamic insect populations.

QDAF's Jamie Hopkinson monitors SLW.

"We have found moderate resistance to Admiral (pyriproxyfen) in one location in Northern NSW this season," Jamie said.

"Concerning for us is that pyriproxyfen is a cornerstone product for SLW control, and should be limited to no more than one application per season.

"There is also widespread resistance to the neonicotinoid Shield (clothianidin) which isn't registered for SLW but has the potential to cause management problems if used too often to control pests like mirids during the season, as it can reduce the numbers of natural enemies, but leave behind the whitefly as they are resistant.

"The detection of pyriproxyfen resistance and the anecdotal reports of increasing spraying going on in general is a concern and it's great to see this industry conducting the IPM workshops around the regions."

NSW DPI's Dr Grant Herron surveys insecticide

resistance on a variety of pests including mites and aphids. Part of Grant's CRDC-funded team is NSW DPI entomologist Kate Marshall who is developing a method for testing mirids for insecticide resistance, as traditional methods do not work as mirids do not transit well and are difficult to establish in culture.

"IPM is the key to successful insect control because it includes all available control tools to achieve economic control," Grant said.

"If you suspect resistance has developed in your farming system remember you will usually not spray your way out of a resistance problem – just further into one."

Resistance to abamectin in two-spotted mite (TSM) was rarely detected before 2010-2011, when resistance was found in three out of the four TSM strains tested. Since then abamectin resistance has been regularly detected increasing in both level and abundance.

Two-spotted spider mite has a history of developing resistance, as testing over has demonstrated over many years showing resistance forming to dimethoate/omethoate in the 1970s, through to bifenthrin in the 1990s and abamectin today. TSM resistance continues to evolve in Australian cotton and most recently caused chlorfenapyr failures.

Grant's 2015-16 test results show that future effective use of bifenthrin (Talstar) against TSM may not be possible as 100 percent of strains tested contained resistant individuals. This is compared to 2014-2015, where eight out of nine (89 percent) of strains tested contained resistant individuals.

"A common use pattern for abamectin has been to apply it in combination with mirid sprays as an 'insurance spray' against mites," says CottonInfo IPM Technical Specialist Sandra Williams.

"Mirid sprays can be disruptive to beneficials so the inclusion of abamectin reduces the risk of subsequent mite outbreaks – however, this practice may ultimately lead to abamectin failure against mites as it is still selecting for resistance in the mites even when they are at low levels.

"A wide range of beneficials will attack mites as food and in the low spray Bollgard environment, and beneficial abundance has broadly increased. This has meant that over the past 10 years mites have gradually declined in frequency as a problem.

"It is concerning that although we don't really see mite issues in Australia, we are seeing resistance, due to the use of prophylactic spraying..."

"This would suggest that insurance sprays against mite outbreaks in most situations may be unnecessary, and may be having a negative impact by increasing the levels of abamectin resistance.

"Instead an alternative strategy to spraying is to monitor the mite population closely and the presence of predators in mite colonies – including thrips."

Tracking the mites over several samples will indicate if they are decreasing (effective predation), static (possible effective predation) or increasing (insufficient predation). This can help in deciding if addition of a mite spray to a mirid spray is justified. Only if the mites are in reasonable numbers and increasing quickly would the addition of a mite spray be justified – and the selection of miticides should be in line with the IRMS. Further, selection of mirid control options that have less negative effect on beneficials and less risk of flaring mites will also further reduce the risk of mite outbreaks.

The old foe – Helicoverpa

The IRMS advocates the use of *Helicoverpa* selective insecticides for supporting IPM in cotton. The windowing of these products in the strategy is designed to reduce selection pressure which is important, especially in the current season given the high *Helicoverpa* pressure particularly in Central Queensland.

Dr Lisa Bird of NSW DPI leads the *Helicoverpa* resistance monitoring research on behalf of CRDC and says recent resistance monitoring results from Central Queensland indicate the frequency of emamectin benzoate and chlorantraniliprole is stable and still at low frequency in the *H. armigera* population.

"However, indoxacarb resistance is elevated compared with the same time last year and is also markedly higher than last year's industry-wide average," Lisa said.

"This may indicate that a trend is emerging with indoxacarb resistance and highlights the need for compliance with the IRMS and using IPM for minimising resistance risk to this and other key selective insecticides."

Using thresholds

"Industry threshold provide guidance on when to control pests so as to maintain yields and quality," CRDC R&D Manager Susan Maas said.

"However we are seeing some concerning trends emerging and need to be proactive in our approach to insect management through IPM.

"It is concerning that although we don't really see mite issues in Australia, we are seeing resistance, due to the use of prophylactic spraying. This was flagged in the IRMS this year where the need to use thresholds was highlighted.

"Knowing thresholds for control of insect pests are aces we hold in our hand: we know what

populations have to be at to start causing damage, yet we are seeing untimely or unnecessary applications. This unnecessary spraying can then trigger problems in other pests and the problem amplifies."

With this year ramping up to be a high pressure year, maintaining beneficial predators is going to be more important than ever and crop managers must choose products wisely in terms of the flow-on and flaring effect they may have later in the season. This signifies the need for IPM to be a year-round program.

IPM as a whole of season approach

To grow high-yielding crops pest management must be viewed as a 'whole season' approach. Early season insect management impacts late season pressure.

"For example what are you doing for thrip management now? And how will that affect your options late season?" Susan says.

"We also need to get away from the thinking that because individual fields or hotspots have reached their threshold that the whole farm needs to be sprayed.

"If you hit mirid threshold in one field – don't spray the whole farm – keep some beneficials in other areas."

Regular flaring of insects such as SLW and mites can be a symptom of a loss of beneficials earlier in the season.

"If you have a lot of beneficials these pests can be less of a problem to manage," Susan says.

The concern is we are seeing whitefly problems year-on-year which suggests they're no longer just based on seasonal conditions - and at the same time we are seeing rising resistance levels to the best product we have for control."

What happens when there are no control measures?

Mealybug is a pest that there are no good chemical control options for – it is only through IPM this pest can be managed.

The recent detection of Solenopsis mealybugs in Victoria is troubling to Susan Maas.

"When mealybug show up you will be looking back through what you've done during the season and wishing you had an IPM approach from the start," Susan said.

IMAGE: MELANIE JENSON

For More

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Cotton Pest Management Guide 2016-17
Available on-line at www.cottoninfo.com.au/publications/cotton-pest-management-guide

SANDRA MCDOUGALL

Cotton can compensate in the south

Ground-truthing of economic thresholds and compensation trials for thrips in southern NSW has shown that spraying this pest early season may not be necessary in the effort to avoid yield loss.

A CRDC research project undertaken with NSW DPI's Dr Sandra McDougall and team at Yanco has been investigating the suitability of the industry thrips thresholds in the relatively short season southern growing regions.

In the commercial-scale experiments, which trialled thresholds of unsprayed; one thrips per plant; and 10 thrips per plant, the researchers saw no significant difference in yield at the end of the season.

"Taking into account yield variation across the paddock, we found that the early season thrips treatments did not translate into a yield difference. There wasn't even a trend with the unsprayed treatments having lower yields," Sandra said.

Sandra also found in a small plot trial simulating thrips damage by defoliating seedlings at two, four and six-leaf stage that cotton plants were able to compensate for the leaf loss. Removing all leaves on the three occasions did delay maturity by eight to 18 days compared to the undefoliated and the treatment that removed 75 percent of each leaf over the three years of trials.

Defoliating three in four plants resulted in a slight delay in maturity. In two of the three years the grower cut the crop out after the defoliated crop had caught up and there was no yield difference.

"Due to the short season here, avoiding early season damage has been paramount, as it was assumed due to the short season there was not enough time for the plant to compensate," Sandra said.

"We found through simulated thrips damage trials that it did cause delays in maturity, but the plant could compensate if cut-out and defoliation was managed around this.

"Beneficials are the best thrips control – yet we often hear that they that are not prolific early season in the south, so early insecticide sprays don't affect them.

"I would say that even though they can't be seen in the crop, that doesn't necessarily mean they are not present – and it could affect how they will increase going into the season."

CottonInfo IPM Technical Specialist Sandra Williams says this season growers may be especially nervous about high thrips numbers due to the climatic conditions through winter and spring which favour population growth.

Previous research has also shown using sprays like fipronil early season to control thrips increases the likelihood of flaring other pests such as mites and silverleaf whitefly and wiping out beneficials.

"High thrips numbers are seen after good winter and early spring rains, along with large areas of winter cereals, as is the case this year.

"In light of this research and the flaring and resistance issues in other pests partly caused by early season thrips management we are suggesting that crop managers carefully consider control options.

"We understand the need to protect the crop and yield, especially in short season areas, but the threat of resistance in silverleaf whitefly and mites is real, and sound IPM is the only way we can safely control cotton pests to ensure future viability of cornerstone products, avoid increasing/flaring populations of pests and destroying beneficials.

"The *Cotton Pest Management Guide* has the information growers need to make sound IPM decisions, and we can't stress enough how valuable this publication is to the industry, growers and consultants."

Technical Officer Sarah Beaumont, with Emma O'Connell and Hannah Draper hand cutting the 75 percent by leaf treatment in the defoliation trial at Huddersfield, Darlington Point.

For more

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Cotton Pest Management Guide 2016-17
w www.cottoninfo.com.au/publications/cotton-pest-management-guide

IPM the only option

There are no insecticides registered for the control of solenopsis mealybug in cotton.

Controlling pests means controlling weeds. Mealybugs multiply on a wide range of hosts and may initially breed on weeds before migrating to cotton crops. They will also breed to very high numbers on ratoon and volunteer cotton in winter, moving on to the roots during cool weather, and then as soon as temperatures begin to rise, moving above ground to recommence breeding.

According to the cotton industry experts on the solenopsis mealybug, Dr Richard Sequeira and Dr Moazzem Khan, the best way to control them is through maintaining beneficial insects in and around the farm and vigilance around removing weeds and rogue cotton from fields, channels and roads.

However, maintaining beneficials in the system can be tricky, especially when using foliar sprays to control sucking pests such as mirids early or mid-season, which also knock out beneficials.

"It is most often mirid sprays which disrupt the good guy/bad guy balance and that is when mealybugs can flare," Richard said.

"In their natural environment with no human intervention, beneficial insects will get on top of mealybugs, but we do need to look at chemical options if we are seeing early season damage.

"Mealybugs differ from other pests in that we do see low level infestation across a field, but mealybugs don't typically affect a full field – they are mainly found in patches or hot spots."

Richard, Moazzem and a team of technical support staff are currently working on a CRDC project to assess chemical options for mealybug control. The team hopes to have recommendations for use for managing hotspots by the end of this season.

However there are currently other options.

Managing mealybugs – what to do

- Good farm hygiene – Minimise on-farm sources of weeds, rogue and seed cotton which aid mealybug survival and carryover. The cotton mealybug has a very wide host range of more than 154 plant species including field crops, vegetables, ornamentals, weeds, bushes and trees.
- Do not throw uprooted weeds into water channels; try to avoid physical contact with infested plants as mealybug easily adhere to clothing and implements.
- The removal of affected plants at the early stage of infestation may reduce mealybug numbers in the rest of the crop.
- Preserve your beneficials -Avoid flaring mealybug when managing for other pests.
- Consider release of *Cryptolaemus*, lacewings and/or ladybird beetles in hotspots.
- If intervention to control mealybugs in the field is warranted, consider treatment of hotspots only with products such as crop oils – be mindful of spreading infestations.
- Crop oils such as Biopest oil, Canopy and possibly others, can be useful in managing low-moderate densities of mealybugs through repeated applications –this approach is currently being used successfully in the Dawson/ Callide Valley on commercial cotton.
- Put into practice the industry Come Clean. Go Clean. protocols.
- Good crop management to avoid stressed cotton, as it appears to be more susceptible to mealybug infestation and damage.

Mealybugs on the move

Mealybugs were first detected in cotton in the Burdekin region in Central Queensland in 2008. The pest then caused crop losses in the Emerald area in late 2009 and was identified as the exotic *Phenacoccus solenopsis* in January 2010.
In 2012, a conventional cotton crop west of Dalby on the Darling Downs was severely affected by mealybug infestations. However an adjacent crop had very low numbers. The main management difference between the crops was the use of insecticides. The crop with high mealybug numbers was sprayed with seven different insecticides targeting tipworm, *Helicoverpa*, aphids and green vegetable bugs.
Earlier this year, solenopsis mealybug were detected in Victoria. While this detection wasn't in cotton, it certainly highlights that this pest is highly mobile and able to establish in new areas. Cotton is one of its most favoured hosts, and solenopsis can be extremely damaging in cotton, especially in hotspots where high density populations result in symptoms of direct feeding such as yellowing, stunted, twisted growth, defoliation and plant death. Indirect damage can include the reduction in photosynthetic capacity resulting from sooty mould growth on honeydew excreted by the mealybugs.

Healthy, attractive and rogue free

Research by Dr Mary Whitehouse has reiterated the need to keep refuges clear of volunteer Bt cotton, and to have highly-effective, well-placed refuges to impede the movement of *Helicoverpa* larvae between crops to avoid the risk of resistance.

CRDC supported the research which examined the movement of large *Helicoverpa* larvae and found they are more likely to move from less palatable crops and/or pigeon pea refuges into Bt cotton if these plants are actually touching. Refuges and Bt cotton crops should still be situated close enough so moths can easily mingle and breed, as per the two-kilometre rule in the Resistance Management Plan (RMP).

The principle of refugees

Pigeon pea refuge (left) with large susceptible (SS) *Helicoverpa* larvae and pupae, producing large numbers of susceptible moths. On the right is a fully resistant (rr) larvae, pupae and moth surviving on Bt cotton. A small barrier/gap (eg channel) stops large larvae from pigeon pea crawling into Bt cotton and surviving, but still allows the resistant moth (rr) from Bt cotton to mate with the susceptible moths (SS) from pigeon pea and producing susceptible offspring that only carry one resistant gene (Sr-black crosses) which are then killed by eating Bt cotton.

Bt toxins kill larvae by attaching to its gut wall and forming holes in it. Bt-resistance genes work by changing the gut wall so Bt toxins cannot attach to it. Larvae can also develop 'tolerance' to Bt toxins by activating more agents to attack the toxins before they reach the gut wall. Tolerance is not a genetic change, but a change in gene activation and it is not as effective as a genetic change.

Australian researchers have found susceptible larvae developing in Bt cotton and Mary initially suspected they were surviving by feeding on the cotton's flowers and bolls, which produce lower levels of Bt toxins than other plant segments.

"As part of our CRDC-funded project on managing Bt resistance with refuges, and in collaboration with Dr Mahbub Rahman from the University of Adelaide and CRDC summer scholarship student Sharna Holman, we tested whether larger or smaller larvae could survive on low levels of toxin, and if they survived, if their offspring could better tolerate Bt toxins," Mary said.

"We tested more than 4000 larvae and found those exposed to Bt toxins as larger larvae were much better at surviving than those exposed only as younger larvae.

"We also found that only the offspring of *Helicoverpa* exposed as larger larvae could better tolerate Cry1Ac.

"We then tested larvae on bolls and flowers of Bollgard II and found the same thing: older larvae survived better on Bt cotton, and their offspring survived better on low levels of Bt toxins."

Managing a well-placed, healthy and attractive refuge is a must. If a refuge becomes unpalatable and it is surrounded by healthy Bt cotton with many young bolls, research shows two problems are likely to arise. Larger larvae move from the refuge into cotton, cause damage and still survive. Secondly, the offspring of that larvae could better tolerate low levels of Cry1Ac and Cry2Ab (Vip3A has not been tested) giving them an advantage on Bt cotton should the concentration of Bt toxins drop.

For more

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COMMENT: WITH CROP CONSULTANTS AUSTRALIA

Keep talking, keep listening

With the 2017 cotton crop well and truly in the ground, Crop Consultants Australia says it is timely to have a look over the fence and back into the winter cropping season, which has presented its own set of challenges.

MELANIE JENSON

With so many chickpea crops around this season, adjacent cotton growers need to be on the lookout for increased egg lays of *Helicoverpa armigera*.

This year (2016) we saw record chickpea plantings in Australia, however climatic conditions created mixed outcomes for growers, and many learnings from the experience can be transferred to the cotton industry and this 2016-17 season.

During our recent run of dry seasons and reduced irrigation allocations, it has been easy to believe that rain and irrigation was the silver bullet to a successful season. However with the 2016 winter cropping season being the second wettest on Australian record, it has reminded us that good years also present their own set of challenges. Towards the end of this 2016 winter cropping season, wet paddocks, high pest pressure and chemical shortages were an all too familiar story for many growers.

These issues highlighted the importance of a timely, co-ordinated approach to communicating with industry, particularly in the areas of product availability, new and emergency permit registrations. Throughout last season, CCA played an active role in facilitating this information flow within the pulse industry and forming a conduit between researchers and growers. Last season saw some excellent examples of the effective use of social media to quickly spread the word about regional outbreaks and permit approvals. This was backed up by valuable 'go to' on-line resources such as the APVMA product database and APVMA permit search tool.

It highlighted the need for an area-wide management approach to pests and disease.

This cotton season we are seeing many growers entering the industry for the first time, but it is important to remember that the decision to grow cotton has been in some cases entirely opportunistic, coming off the back of failed chickpea crops. If these failed chickpea crops are still in paddocks, adjacent cotton growers need to be on the lookout for increased egg lays of *Helicoverpa armigera*. Viable chickpea crops, once harvested can also push these pests into cotton. Coupled with the likelihood of overall high insect pressure comes growing indications that we may again be facing chemical shortages during this cotton season.

We need to remember that in some cases shortages are not due to a shortage of supply worldwide. Overcoming these shortages at a local level requires careful planning, accurate forecasting, effective communication and willingness by those who make an order, to commit to a purchase to secure their product. Co-ordination and effective communication right across the cotton industry is vital if we are to mitigate these potential issues.

As an association for agronomists who work across not only industries, but also regions, CCA and its members are in the unique positon of being able to facilitate many of these discussions, and we are committed to ensuring an ongoing information flow to industry.

We are urging growers and consultants to work closely with each other, cotton industry researchers, technical specialists, regional extension officers and industry bodies like CRDC to ensure communication is an open two-way street, as awareness is the most effective tool to ensure a healthy, prosperous and sustainable industry, more ready to foresee and overcome issues should they arise.

For more
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Improving disease management capacity

RUTH REDFERN

CRDC directors visited Namoi Valley farms in August where the focus was on Verticillium, the CRDC-supported pathology diagnostic services, biosecurity preparedness and surveillance capacity. CRDC has since announced a new approach to the annual disease surveys and is working closely with researchers, CottonInfo and growers to better understand, diagnose and manage issues like Verticillium wilt.

The CRDC annual disease surveys project has undergone significant changes, which are effective this season.

The core aim of the surveys remains the same – to ascertain the type and level of diseases present in cotton fields across NSW and Queensland, as well as detect exotic diseases. A major change is that separate surveys undertaken by NSW DPI and QDAF pathology will be combined into one project, led by QDAF Pathologist Dr Linda Smith. This new project will have the added benefit of a greater focus on using geospatial digital agricultural analysis to make better use of the data collected in terms of identifying and testing best practice and providing links between soil characteristics, yield and disease, for example.

"The disease survey project has been completely reviewed to improve impact and outcomes for industry," said CRDC's General Manager R&D Ian Taylor.

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"CRDC is expanding its pathology capacity and capabilities in cotton and focusing on better collaboration and more strategic use of the information we gather," he said.

"It will also see the employment of a further pathologist and technical officer through NSW DPI Farming Systems who will be attached specifically to this project giving increased pathology capacity in NSW.

"The CottonInfo regional extension officers will also be more engaged in pathology surveys, to broaden monitoring capability to ensure the pathologists are aware of and can engage quickly with emerging issues."

Enquiries and sampling

The protocol for disease samples has changed in NSW. All plant samples from NSW should go to Elizabeth Macarthur Agricultural Institute (EMAI), while testing in Queensland will remain at the QDAF Ecosciences Precinct in Brisbane. It is important that suspected diseased plant samples are not sent to ACRI, to avoid biosecurity risks. For details on where to send NSW samples contact David Larsen, who will be co-ordinating this role until NSW DPI appoints the new survey team pathologist. Queensland enquiries should be directed to Linda Smith.

"The focus of early disease survey for 2016-17 is for CottonInfo to gather data for sites ahead of a late season survey," Linda said.

"The pathologists' focus will be to respond to new/emerging issues: and if anyone has any disease concerns – please contact CottonInfo Disease Technical Specialist Sharna Holman, your REO, Dave Larsen or myself. Once the new pathologist is on-board, we will ramp up to full survey capacity.

"We are really excited about this new project and our increased capacity and the use of the data we gather for such things as correlating yield mapping to disease data points and including variables like weather and cropping practices.

"The format of this new project will allow us to get so much more out of the data we collect, which builds a much clearer picture of the causes and hence management of diseases in cotton."

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Growers & researchers join forces

A collaborative project involving researchers, CottonInfo regional extension officers and cotton growers is helping to identify and tackle disease in Northern NSW through on-farm trials.

The CRDC-supported trials, which are being conducted by CottonInfo's Regional Extension Officer for the Namoi, Geoff Hunter and QDAF pathology group, headed Dr Linda Smith, aim to build on the disease surveys conducted through the *Diseases of Cotton XI* and the *Fusarium wilt management in cotton* projects.

The surveys have identified Verticillium wilt as a major issue in the Upper and Lower Namoi and Gwydir valleys, and the trials aim to help researchers and growers better understand, diagnose and manage the disease.

Six growers who have been heavily affected by *Verticillium* are actively involved in the trials, enabling trials to be conducted across six sites at Wee Waa, Narrabri, Boggabri and Moree. The trials, that will run for at least three years, involve different rotation crops for cotton, to help better understand the behaviour of the *Verticillium* strains, their inoculation levels and hosts, and the impact of nutrition and soil on the disease.

"*Verticillum* is costing us in terms of both yield and dollars," says cotton grower Andrew Watson from Boggabri – one of the six growers involved in the trials.

"These trials will provide critical information to me, the researchers and importantly, other growers, about how to best manage vert.

"Being involved in a trial is significant in terms of both time and money.

"I have estimated that my direct costs and my opportunity costs, in terms of a crop I could have grown on the 18 hectares I have dedicated to this trial, equal around $11,000 per annum.

"But these costs are far outweighed by the knowledge I will gain from these trials – the knowledge is far more valuable to me and the broader industry."

Linda Smith says that this joint effort means all the data will be shared, and more can be learned and the benefits of the different rotations.

"Grower-led trials help to ensure that the research considers the farming system and the results are meaningful," Linda said.

"This was a key learning in the approach to *Fusarium* research.

"CottonInfo have been pivotal in setting up these trials and providing that linkage between research and industry.

"It is also about managing these *Verticillium* hot spots within the field, nutrition, soil characteristics and inoculum levels.

"When we have a better understanding of what is going on the fields we can develop research and solutions to this disease."

MELANIE JENSON

"These trials will provide critical information to me, the researchers and importantly, other growers, about how to best manage vert."

– Andrew Watson

For more

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IMAGE: MELANIE JENSON

Looking to the world for answers: Management options for Verticillium

Verticillium wilt is not a disease unique to Australia or the cotton industry, and overseas researchers are finding practical management strategies, says industry pathologist Dr Linda Smith.

Dr Linda Smith and Dr Karen Kirkby both attended the International Verticillium Symposium in Slovenia in early October.

Of particular interest were some similarities with emergence of the disease in hops.

"In England, it took 30 years for resistant varieties of h ops to become susceptible to Verticillium wilt, and this is because *Verticillium* developed more virulent strains over this time period," Linda says.

"I found this interesting because this is a similar time-frame to what we've found in Australian cotton and begs the question 'have more virulent strains developed here over the time of the first detection 30 years ago?'"

Linda says detailed discussions with Professor Jiminez-Diaz on soil solarisation to reduce inoculum population in the soil pre-plant suggests that this approach would be effective to control *V. dahliae* in cotton in Australia. Soil preparation is very important for this approach to be effective.

"Soil needs to be cultivated sufficiently to break down clods to a fine tilth and watered to field capacity to enable heat penetration at depth," Linda told *Spotlight*.

"Trials in Spain with cotton showed that soil solarisation for six to 10 weeks reduced the population of *V. dahliae* in the top zero to 40cm soil layer to undetectable or very low levels.

"Under these criteria the beneficial effects lasted three years and this management strategy is directly applicable to the Australian cotton industry. This will be trialled for effectiveness against Verticillium wilt of cotton in Australia in collaborative trials with industry researcher Dr Paul Grundy."

Green manure

US researcher Dr Dan Chellemi presented a paper on methods to promote the biological buffering capacity of soils by integrating ecologically-based principles into the design of crop production systems.

For 50 years growers in the US have been fumigating during the most resistant phase of the *Verticillium* lifecycle – microsclerotia.

"Pre-plant disinfestation is a flawed approach for disease control," Linda explains.

"What we need to do is target the most susceptible stages.

"Current control methods ignore the reproductive and dispersal phases of the lifecycle and fail to take advantage of the competitive incompetence of *V. dahliae* in soil ecosystems."

CRDC will be partnering with NSW DPI to test potential innovative solutions to cotton diseases. This project will be able to consider key diseases, their lifestyle and the farming system to identify the best time and approach to introducing potential control products such as fungicides.

Amendments for suppression

Adding soil amendments such as broccoli residues and chitin (found in the cell walls of certain fungi and algae) to increase the population of beneficial soil microflora results in disease suppression. Professor Krishna Subbarao, also from the US, presented data on the microorganisms responsible for control of *Verticillium*.

For many years it has been believed that the mechanism for controlling Verticillium wilt in cauliflower with the incorporation of broccoli residues was the production of volatiles toxic to the pathogen.

"New research presented at this symposium has shown that a shift in the soil microflora is responsible for disease suppression, with Myxobacteria breaking down the melanin in the fungal pathogen," Linda said.

"In conversation with Professor Subbarao following his presentation, he said that forage sorghum as a green manure crop would have the same potential as broccoli to alter soil microflora to manage disease.

"Once forage sorghum is one to one-and-a-half metres tall, it could be mulched and incorporated into the soil, which must be moist to enable microorganisms to become active and break down vegetation.

"New research has shown that a shift in the soil microflora is responsible for disease suppression..."

Tool to test inoculum levels

A new CRDC project undertaken with NSW DPI Pathologist Dr Karen Kirkby will specifically focus on Verticillium wilt and developing a tool for growers to quantify the inoculum levels of the pathogen *Verticillium dahliae* in soil.

"New knowledge developed during this project combined with 30 years of NSW DPI survey data will allow the team to use their extensive expertise in cotton pathology to develop key components of decision matrices which will allow growers and managers to assess the risk of where and when to plant cotton," Karen said.

"A key to combating the pathogen that causes Verticillium wilt in cotton is gaining a better understanding of the genetic makeup along with studying the diversity of isolates collected to date throughout different cotton growing areas.

"This work will focus on transmission pathways through the soil inoculum quantification assay, a highly anticipated tool for use in cotton disease management that will be developed in this project."

Successful development of an accurate and rapid soil inoculum quantification laboratory tool will assist the cotton industry to take a rational, informed approach to planting decisions and management of Verticillium wilt.

For more
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"Forage sorghum would be a more suitable crop than broccoli for Australian cotton producers to include in their cropping regime and should be investigated for its effectiveness in controlling Verticillium wilt.

"We are currently investigating if this is treatment that should be included in cotton rotations here."

Identification in-field

The latest research for fast detection of *V. dahliae* using a portable instrument (ICGENE) and a molecular kit suitable for use in the field was on show at the International Verticillium Symposium.

This kit using plant tissue is cost effective and more sensitive than real-time assays. The device can be operated using batteries and can therefore be taken into the field for on-site identification and the analysis only takes one hour. Linda is making enquiries to purchase a kit. The current method of identification requires suspected samples to be plated out on growth media in a laboratory, and because *V. dahliae* is particularly slow growing, can take up to six weeks for confirmation of ID.

"While this kit does not identify strain of *V. dahliae* (it will not differentiate between defoliating and non-defoliating pathotypes) or Vegetative Compatibility Groups (VCGs), it would be extremely beneficial for quick identification of *V. dahliae* on-farm.

"However this test kit would be of real benefit when a new field has plants expressing wilting symptoms with vascular discolouration, given the difficulty to differentiate between *Fusarium* and *Verticillium*.

"Quick analysis to determine if weeds present in an infested field are hosts of *V. dahliae* would also be highly beneficial.

Early detection of Verticillium

Spain's Dr Navas-Cortes is an expert on the development of risk maps for fields and regions using thermal and hyperspectral imagery for early detection of Verticillium wilt. Since the symposium, Linda has been in contact and says the Spanish researcher is keen to collaborate with her in developing this technology for Australian growers.

"Many Australian cotton growers are interested in this technology for early detection of *Verticillium*," Linda said, "so coming out of this conference we have brought back a lot of new research and technology which we can further test here in Australia.

"This is good news for our growers who have been so badly affected by this disease."

Tackling herbicide resistance

Stopping weeds setting seed and diversity of management are the cornerstones of integrated weed management and key to clawing back the upper hand on herbicide resistance.

CRDC partnered with Independent Consultants Australia Network (ICAN) and CottonInfo to bring 16 weed management workshops to growers and consultants across 14 locations from May to August this year.

Growing resistance to herbicides in both dryland and irrigation systems means many growers and consultants are reassessing the range and diversity of weed management tactics used in Australian cotton production systems. Fourteen of the weed management workshops were developed by ICAN with two separate events developed by Crop Consultants Australia designed specifically for consultants.

Loss of diversity

ICAN's John Cameron said these workshops were extremely timely.

"We are at a point where cotton growers will be confronted by management changes in terms of weeds," he said.

"A loss of diversity in the farming system and chemistry and tactics used in weed management has led to resistance to a number of herbicides, starting with glyphosate.

"What we need to remember is that every time we use a herbicide we are creating a selection event.

"Unless you do something different to stop survivors going to seed you've changed the frequency of resistance in that population for all future years."

Eliminate seed set

John said stopping weeds setting seed

Surviving glyphosate resistant awnless barnyard grass plants among dead susceptible plants and other species.

is the cornerstone of integrated weed management (IWM). If weeds survive after treatment, it's these weeds that are the ones most likely to be resistant to the last herbicide used. The surviving weeds are also the main source of next years weed problem.

The workshops identified the variety, difference and severity of weed issues in farming systems.

This was due to a range of factors, some known and others unknown, yet climate, prevailing weather conditions, management and field history all played a part.

"For example the southern systems have an entirely different suite of problems to other regions.

"Due to the cooler starts and shorter season, it becomes a lot more risky to use a pre-emergent herbicide at sowing than in areas where early crop growth is more vigorous and the risk to crop establishment is less. In southern NSW, the difficulty of including pre-emergents at sowing, places more emphasis on management strategies later in the crop."

Cotton is well served for pre-emergent herbicides, with multiple options available for pre sowing, at sowing and early and mid-season laybys. These include some new registrations for layby applications of products such as S-metalochlor and pendimethalin. These layby options provide a higher level of crop safety than several of the 'at-sowing' options, especially in valleys where cold wet conditions during crop establishment can interact with herbicides and lead to crop damage.

Eliminate seed set

However even accounting for regional climate variations, NSW DPI weeds research agronomist Dr Graham Charles said diversity was not only between valleys, but within valleys.

"We saw how many of the workshop groups had quite different issues, constraints and attitudes," Graham said.

"It emphasised why we need to work with small groups right through the industry to work on their individual issues.

"As an example in the Namoi Valley alone the Boggabri group had some serious resistance issues and were broadening their weed management approach, taking on more residual herbicides and cultivation.

"Whereas the Spring Ridge group had exposure to glyphosate resistant annual ryegrass in no-till dryland systems and were looking to be proactive and broaden their weed management approach.

"The issues are not even necessarily uniform over a valley and each grower will need to develop their own response right down to individual field level.

"The attitude of the workshops to give the growers the tools and then let them work out where to use them seemed to be right on target."

How should the industry as a whole tackle this diversity?

"There's been a degree of complacency with glyphosate but I think this industry has more than enough technical prowess to handle it," John Cameron said.

"We have a highly capable, technology efficient group of growers and consultants who are keen to take up technology to tackle this issue of resistance and managing hard to control weeds.

"Given that 1982 saw the last

international release date of a new mode of action that we use in broadacre cropping in Australia and nothing new is coming out in the short term, we are burning quickly through the existing suite of post-emergent herbicides.

"This is prompting growers to shift to more pre-emergents.

"The question is how to best accomplish this shift from mainly post-emergent to pre-emergent herbicides in an ultra-high yield crop system.

"We need to be ready and prepared for a herbicide depleted environment and ask 'what do I need to do to remain farming profitably and flexibly?' If we don't we will soon be putting the chippers back into the paddock.

"Indeed, with the goal to move the weed seed bank into decline every year, having chippers in some paddocks each year to put the finishing touches onto all the good work that has already been done and really stop weed seed set for the coming seasons, makes sound economic sense.

"Two key action items that all growers should adopt, are to have a management plan that has diversity and is targeted to reduce the weed seed bank with few survivors for each field. The other component is that when a spray failure occurs and resistance is suspected, don't just test to confirm resistance, test to see what still works for next time and ensure all survivors are eliminated before they can set seed.

"Confirming what's just failed is a good start but that's probably a tenth of what you need to know."

Further workshops are planned for 2017.

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Robots coming to a paddock near you

Very soon Australian cotton farmers will see robotic platforms roaming paddocks, seeking out weeds and destroying them.

A pair of Swarmbot 3s autonomously spraying weeds in fallow near Emerald, QLD.

CRDC recently commissioned a study to review technologies enabled by robotics to improve weed control in Australian cotton farming systems, and to identify research gaps. The review included visits to key researchers at University of Southern Queensland (USQ) and The Queensland University of Technology (QUT) who are developing ground-breaking robotics for use in agriculture. The study found that while much has been happening in this arena in terms of research, at this stage there has been limited development and commercialisation of the technology.

While four unmanned agricultural ground vehicles have made it past the concept stage, only one – the Australian SwarmBot from SwarmFarm – has been commercially launched. These unmanned ground vehicles however still need to be equipped with tools for weed detection and control as well as other crop management tools.

Two weed detector or sensing units, the WeedSeeker and WEEDit have been commercialised and are available in Australia. These units detect green on brown so are ideal for fallow use, detecting weeds against soil and stubble backgrounds.

A third weed detector, the H-Sensor, is undergoing development and has the ability to detect green on green meaning it will be useful in-crop to distinguish weeds from crop as well as between weed species. A number of research and development corporations (RDCs) including CRDC has invested in a National Centre for Engineering in Agriculture project that enables green on green detection, including selecting grass weeds in crops.

Many weeding tools and non-herbicidal tactics, for example steam, have been researched but few have been developed, or are not readily accessible for robotic application. Microwave technology and a targeted tillage implement for weed control are being developed in Australia; the latter for the grains industry to tackle herbicide resistant weeds, but is not being developed for robotic enablement.

Unmanned platforms have the ability to move slowly and even stop for weeds but can also operate 24/7. Tools that are very suitable for application

with unmanned platforms may not be practical for use with tractors, however a swarm of unmanned platforms can be supervised by one person with the ability to simultaneously undertake other management tasks.

Future opportunities

Key opportunities for robotic enabled management were identified in the study. These are:

- Spot spraying weeds and rogue cotton plants in-crop and in fallow/low-density situations or survivors of broadcast weed management applications: or perhaps patches of hard-to-kill and or resistant weeds; using alternate modes of action products.
- As above but by spot tillage (or other non-chemical treatment).
- Application via spot or patch spraying of effective but expensive herbicides that may not otherwise be used due to cost.
- Weed surveillance – monitoring and mapping weeds in the paddock; growers know exactly where their weed issues are; monitoring for herbicide resistance survivors. The robots effectively become the eyes of the grower but at ground-level.

While it is not foreseen that robots should undertake all on-farm weed management tasks, but rather the more tedious and time consuming tasks that require maximum efficacy results. Of course, if weed populations are driven to very low densities, then robots may replace the broadacre spray boom.

The future of weed management in cotton looks bright and exciting with robotic enabled technology just a few steps away.

For more
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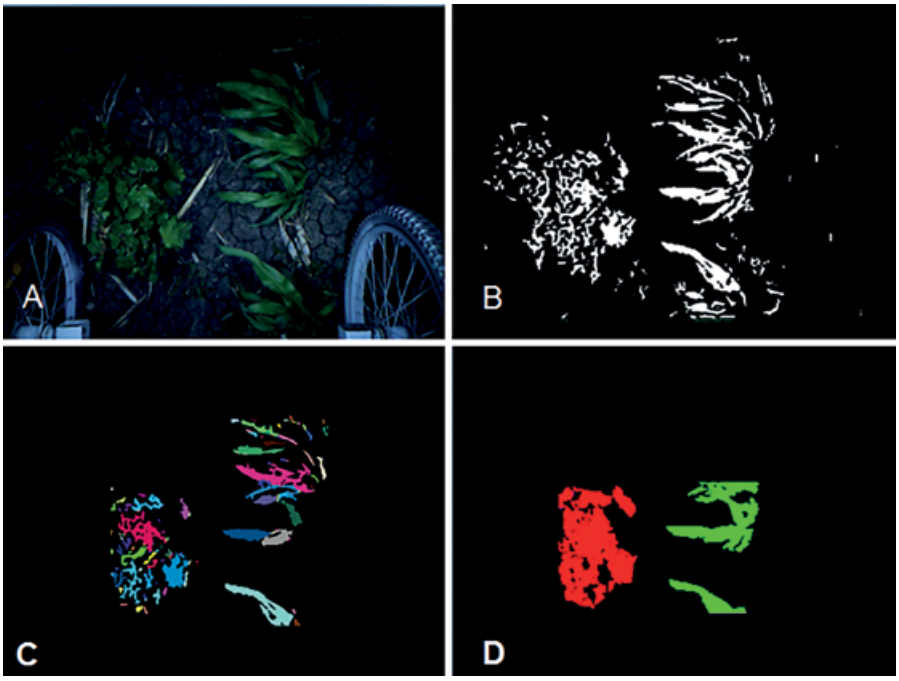


Nowhere to hide

Volunteer Roundup Ready cotton is a significant weed issue for the Australian cotton and grains industry.

A key component of volunteer cotton management is the ability to detect volunteer cotton in fallow fields and among other crops. Commercially-available weed spot spraying technologies such as WeedSeeker and WEEDit only identify and spray green weeds in a fallow field and do not discriminate between weed species.

However the ability to detect green on green identification is being developed with the commercial development and evaluation of a machine vision-based weed spot sprayer with support from CRDC, Sugar Research Australia and Horticulture Innovation Australia.

A project being undertaken at the National Centre for Engineering in Agriculture (NCEA) will build on work undertaken by researchers from University of Southern Queensland (USQ) into on-the-go weed identification in the horticulture and sugar industries to identify cotton in other summer crops.

The USQ technology achieves weed species discrimination via application of machine vision techniques that can include applying colour, shape, depth and/or texture analysis to images from sprayer mounted cameras. Preliminary texture analysis performed by NCEA on video of volunteer cotton in a sorghum crop indicates that volunteer cotton is separable from sorghum and other weeds.

ABOVE: Nowhere to hide. Colour image of a cotton and sorghum plant (A); an image segmented with the plant material shown in white (B); the plant material split into components identified by different colours (C); and the different components classified into cotton (red) or sorghum (green) (D).

USQ is currently collecting real world field data and developing market entry algorithms to provide the basis of a product that can be commercialised. It is anticipated that the project will develop the algorithms this summer and move into a 'proof of concept' field prototype for the following season. The technology will enable growers to implement weed management strategies that reduce herbicide usage and that specifically target volunteer cotton.

Looking below the surface: Lessons from the landscape

In the last edition of *Spotlight* Dr Oliver Knox spoke to several researchers who have an interest in the biology of our cotton producing soils. They talked about the soil biology's abundance, diversity and some management decisions that could help to improve it, but in doing so we really only scratched the surface of what we know…

In this edition Oliver has brought together information from some of the industry's researchers conducting work on our farms' soils and associated environments in areas where we aren't farming. The soil biology of the native vegetation on cotton farms indicates what was probably there before, what we've lost through cultivation and what functional changes this might have on our soils.

IMAGE: MELANIE JENSON

One of the best loved examples of our native vegetation areas are the river red gums and Dr Rhiannon Smith of UNE has been looking at these in the cotton landscape for over a decade.

Of these trees Rhiannon says, "River red gums capture the hearts and minds of Australians and as such, these gums are an important focal point for monitoring riparian health and condition."

Of course this is not all they do.

"Healthy river red gum ecosystems on cotton farms provide important ecosystem services and sequester and store large amounts of carbon, which feeds the soil biota that stabilises soils and riverbanks, stopping slaking and dispersion of soil aggregates, and reducing sediment flows into river systems," Rhiannon says.

"Riparian river red gum forests can store up to 400 tonnes of carbon per hectare, with approximately 40 percent of this carbon stored in the soil, and can sequester an average of 5.3 tonnes of carbon per hectare per year in woody biomass.

"Riparian vegetation dominated by river red gums plays an important role in offsetting carbon emissions on cotton farms."

So the trees are clearly important, but we can go further!

It's a living thing

Dr Kathryn Korbel from Macquarie University is focused on the microbes and animals within groundwater. Kathryn's work has shown that the abundance of trees as well as agricultural practices can have an impact on the groundwater biota (stygofauna and microbes) and potentially water quality. But what are stygofauna?

"Stygofauna are predominantly small crustaceans similar to invertebrates that we find in our rivers, but due to the lack of light in the groundwater environment, these animals are transparent and sightless," Kathryn says.

"In fact, some of them are known to move between ground and surface water when conditions are favourable.

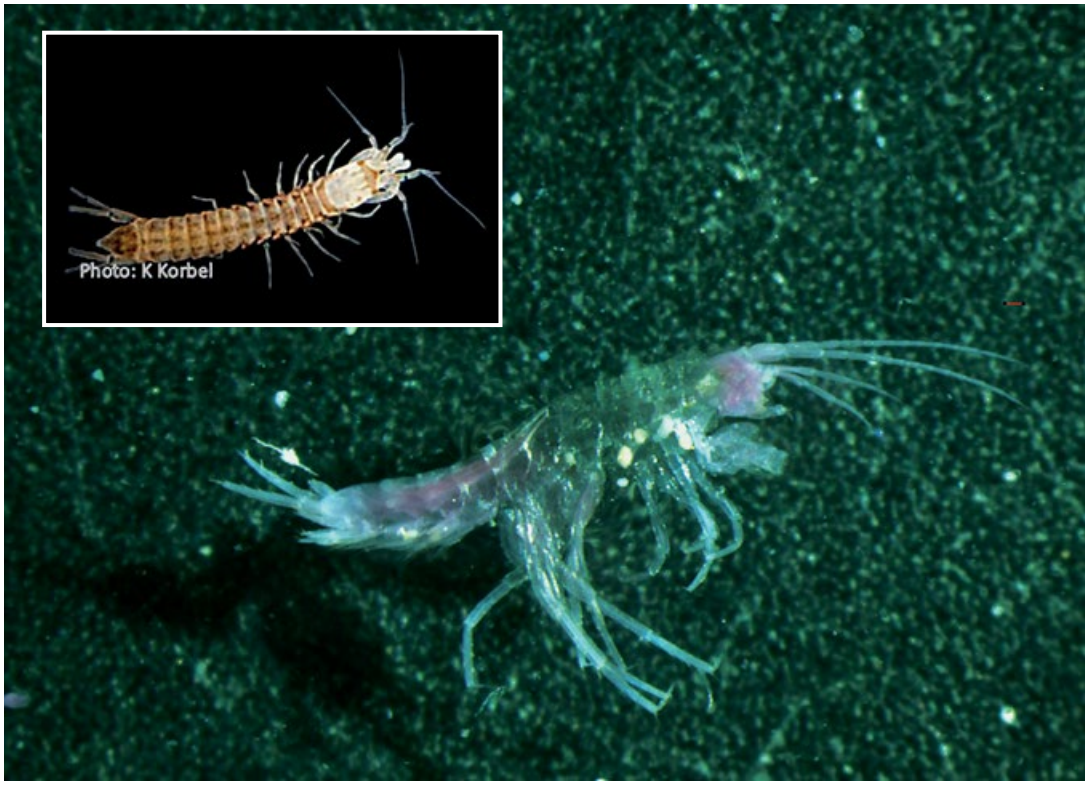
"By looking at these animals we can gauge groundwater quality.

"Our work has also focused on the bacteria within the groundwater, which are believed to be important in influencing water quality, ensuring groundwater remains suitable for drinking and agricultural uses such as irrigation.

"It has become apparent that bacteria are important in the nitrogen, carbon and iron cycles within groundwater, with microbes possessing the ability to degrade nitrates being located in our focus catchments.

"Although more work on this is needed, results potentially indicate microbes may have a role in remediation of contaminated groundwater."

For cotton farms and farmers, this research is highlighting the links between biology in the



PREVIOUS PAGE:
Dr Rhiannon Smith says river red gums sequester and store large amounts of carbon.

MAIN IMAGE:
An amphipod, another of the invertebrates we find living in the ground water depending on its quality.

INSET:
Syncarids, about the length of a 20 cent piece, are a type of stygofauna, blind invertebrates that dwell in out groundwater and can help predict its quality.

groundwater and water quality, which in turn has implications for the wider environment that includes our cotton production systems.

Monitoring quality

The groundwater microbiology and the soil microbiology are also the focus of one of Dr Bryce Kelly's projects in which they started analysing the soil and groundwater microbiology to enable better interpretation of the air and groundwater methane surveys being conducted in the Condamine Catchment.

When Dr Sabrina Beckmann at UNSW started analysing the vertosols from the Condamine Catchment, she noticed that the soil microbial communities found under native vegetation, traditionally fertilised irrigated cotton crops, and bio-fertilised soils were different.

"Farming practices appear to have reduced the abundance of bacteria and archaea in soils when compared to adjacent native vegetation areas," Bryce tells us.

This insight is important, because little is known about how historical farming practices originally altered the soil microbial populations in Vertosols. Modern farming methods appear to be rebuilding soil health from a low base.

The microbiological community controls soil health, plant disease resistance, nutrient uptake, and the production and consumption of greenhouse gases. We can learn from healthy native vegetation soils to guide the way we rebuild the bacteria and archaea in farming soils.

Measuring the chemistry of the ground-level atmosphere tells us a lot about microbiological processes occurring in soils. At the district scale Bryce Kelly and Charlotte Iverach have noticed that cotton farming districts have slightly lower ground-level atmospheric methane concentrations compared to areas of native vegetation. They are now trying to quantify to what extent farming landscapes are a sink for methane.

Bryce is also developing methods for the continuous measurement of nitrous oxide emissions at the district scale. He is measuring continuously both the concentration and isotopic compositions of the gases, which provides insights into sources of the gas. His long term aim is to develop automated greenhouse gas accounting methodologies.

How do we tie the research together?

"We've recognised the role of soil biota in providing ecosystem functions for sustainable productivity and maintaining our soil and water resources in our intensive cotton cropping systems in Australia for some time," says CSIRO's Dr Vadakattu Gupta.

"As others have said, soil microorganisms, along with fauna mediate carbon and nutrient cycles and play a critical role in disease suppression, degradation of agrochemicals and the maintenance of overall plant health and soil structure.

"Crop management practices such as crop rotation, tillage, crop residue retention, fertiliser and agrochemical application have been shown to influence the abundance and composition of soil biota communities with potential impact on biological functions, but currently, there is very little information available comparing the composition of soil microbiology in cotton soils with that in remnant native soils."

Charlotte Iverach, UNSW, sampling greenhouse gases at the soil air interface.

What's the difference?

Rhiannon Smith says river red gums sequester and store large amounts of carbon

Gupta has set about remedying this knowledge gap as part of a larger program called the Biomes of Australian Soil Environments (BASE).

"What we found was a clear difference between cotton fields and remnant vegetation," he says.

"Bacterial diversity in soils has been shown to be influenced both by the soil and environmental factors, so the observed differences in the soil microbiology between cotton fields and remnant vegetation could be partly due to the variation in soil chemical properties, which were seen with organic carbon, phosphorus and mineral N all being higher in the native samples."

There is of course still more to learn about our soil biology and Gupta reminds us to be cautious, as to date the sequencing analysis conducted has been

Macquarie University researchers have been sampling ground water on farm.

limited and multi-site and well replicated analyses is warranted in order to confirm these preliminary observations."

One soil, many facets

So by examining the soil biology in our fields, some of the functions and biology associated with our native vegetation and ground water and what we know about the differences between these.

"We see that there are established linkages between our productive fields, our native veg areas, river systems and our farms within the wider environmental setting," Oliver says.

"We're still learning about the biology in our soils and environment, but generally the more diverse it is the more resistant it is to change and the more resilient it is, in that the soil biology recovers more quickly when a change occurs, so we can keep farming."

Taking soil cores as part of Dr Rhiannon Smith's work on river red gums and their immense value to the landscape.

Coming up…

Over the last editions of *Spotlight* we've taken a brief look at the soil biology of our fields and the influence and importance of our native vegetation, so the final chapter is capturing the views of growers who have recognised the importance of soil biology and in doing so have adopted some of the strategies we've discussed to improve soil biology. Stay tuned for the next edition of *Spotlight* to meet these growers and hear about their methods.

In the meantime, if growers or consultants have any questions about the work being undertaken by these researchers, please feel free to get in touch with them or Oliver via the links below.

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Growing leadership potential

The Australian Future Cotton Leaders (AFCL) program supported by CRDC and Cotton Australia is nearing its tenth year of encouraging potential future industry leaders to realise their full potential.

Co-ordinated by Jo Eady, the course is open to people in the industry keen to improve their personal and leadership skills and engage more closely with the cotton industry. With new intakes every two years, 76 people to date from a variety of backgrounds, from farmers and agronomists to those interested in policy or advocacy have been a part of AFCL.

As the fifth course comes to a close, *Spotlight* caught up with two of the current 15 participants, Emma Ayliffe from Griffith in Southern NSW and David Walton from the Darling Downs in South-East Queensland.

EMMA AYLIFFE, 25

AGRONOMIST – ELDERS GRIFFITH

Coming from a two-million acre sheep station in remote South Australia, choosing a career in the cotton fields of NSW may seem like an odd calling, however Emma Ayliff says it's hers.

Initially being accepted to university to study animal nutrition, a year in to the degree Emma switched to agronomy and the rest is history. She's been working in cotton for four years now and is about to graduate the AFCL program.

"I wanted to stretch my wings away from South Australia so moving initially to Tandou Farms at Menindee gave me the perfect mix of agronomy and the outback," she says.

"I hadn't worked in cotton before, now I love it, I've got the cotton bug!

"When I came into it I just loved it because the growers and consultants knew so much about the crop and the physiology is so well understood and there is so much you can do as no two seasons are the same – and there are so many challenges, but there are so many answers.

"The cotton industry is phenomenal in information sharing – it's an open book between growers.

"I was also part of the CGA at Menindee as secretary, so I also was able to get involved with the wider industry."

As she was relatively new to the cotton industry, Emma says in applying for AFCL it was as much about networking as improving 'leadership' skills. However it turned out to be a lot more.

"I wanted to find out who had the knowledge and experience in the industry," she told *Spotlight*, "but I got a lot more than that.

"The big thing it has given me a better understanding of myself, of my strengths due to my personality and character.

"In a professional sense, having recently moved from an on-farm agronomy role to working with multiple growers, this course has given me the skills to be able to read and work better with people, by being more aware of myself and them.

"Now I'm more aware for example, of how people take in information, it allows me to tailor my work to the client, so it suits the individual and helps me provide a better service.

"It is a big learning experience and you get a lot out of it.

"I've also met a bunch of ripper people from all regions of Australia of different ages, from different sectors of the industry, who all have different experiences who are all keeping in touch.

"To people out there, put your hat in the ring – but when you walk in the door be willing to lay everything on the table, because you will only get out of it what you put in."

"Jo Eady has an uncanny ability to find out what our capabilities are and then work with us to use them"

LEE JENSON

DAVE WALTON, 27

GROWER – DALBY, QLD

"It's like standing in front of a mirror" is how Dave Walton explains the experience of the AFCL.

"It really opened my eyes up," he says, "it makes you realise the type of person you are and appreciate that everybody is different, and to understand your way and understand their way.

"The experience has been unreal, it teaches you how to look at things from different perspectives and how to go about your business in the most effective way."

Dave has recently bought a farm with his parents near Dalby. A big move given a few years earlier he was unsure if he would even stay on the land let alone take over the reins.

Dave had been working for his parents on their former property since leaving school, but had come to a point of uncertainty.

"I was unsure if my future was in cotton farming," he says, "So about two years ago I took 12 months off and went to Canada to get away and have a think about it.

"During that time I decided I wouldn't return to farming but instead study marketing."

However situations change, and so do minds.

"I was back working for my parents for a few months to make some money before uni started and just never left – I realised that is what I wanted."

It wasn't long before Dave applied for the AFCL.

"My sister had been through the course and had been encouraging me for years to do it, but I wasn't sure what I wanted then, but when I did apply it was because I had made that commitment to be a part of the industry.

"From the start just getting the nod to be a part of it was a good feeling, knowing that the selection committee of industry leaders has confidence in you.

"The program facilitator Jo Eady has an uncanny ability to find out what our capabilities are and then work with us to use them to the best advantage for ourselves and others.

"I've never dealt with someone like Jo in a role like that – she made light bulbs go on in my head and allowed me to think a lot clearer, stimulated ideas, and has taught and encouraged me to bring these ideas to light.

"Being in a room with a group of 14 other enthusiastic people that are throwing ideas around is also a big part of this."

These skills are being put to good use on the farm.

"Before the course it feels like I was just doing my thing and not really thinking clearly or innovatively about the future or planning for it.

"Now in our partnership at home Dad and I are throwing around ideas, and as a result our farming business is healthier.

"It's a case of one generation stepping back and one stepping forward."

For more

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Keeping cotton ahead of the curve – CRDC-supported young guns at the GrowAg conference, Reinder Prins, Nicole McDonald and Aaron Kiely.

Big future for big data

Big data, how it can be used and how to leverage it was a major talking point among participants at the inaugural GrowAg conference in September.

CRDC supported three attendees to GrowAg – a gathering of 100 of the sharpest and brightest young people working in Australian agriculture. They were grower Aaron Kiely, consultant Reinder Prins, and CRDC-supported USQ doctoral candidate Nicole McDonald

The forum focused on new technologies, new ideas, smart business, leadership and innovation. It highlighted that a potential major disruptor for the cotton industry was big data. CRDC Program Manager Jane Trindall spoke at the conference about big data and CRDC's investment in this space.

Nicole McDonald said that expert presenters challenged them to think about how a variety of innovations could potentially disrupt farming; and identify actions needed to ensure Australian agriculture would be a beneficiary, not a victim of these innovations.

"Much emphasis was placed on working collaboratively to enhance progress and the cotton industry was held up as an exemplar of how growers and industry bodies work together to ensure Australian agriculture has a strong and sustainable future," Nicole said.

For Reinder Prins, it was apparent in discussions that the path to innovation required getting clear policies in place to protect grower ownership of data, and encouraging responsible sharing of data.

"The cotton industry is in a prime position to use big data to our advantage, so once these matters are resolved we can start to measure more, do analyses, and start using this data to positively influence decisions made in the paddock," Reinder said.

Participants were set the task of contributing to future innovation by turning their new-found knowledge into action.

"The cotton industry already has a strong strategy in place to ensure we attract and retain the workforce we need, but we can always learn from others," Nicole says.

"I met many people from other industries and businesses connected to agriculture interested in workforce development, so I'm now setting up a community to keep sharing ideas and knowledge."

The three cotton industry participants acknowledged that grower's openness to innovation was largely to thank for the industry being well placed to adopt new developments.

"The cotton industry has to maintain its open stance towards research and extension," Reinder said.

"If growers stay open to co-operating with researchers and students and with enough R&D funding good things will continue to happen."

The event was organised with the support of the Australian Government Department of Agriculture and Water Resources and RIRDC.

CRDC's Jane Trindall oversees a major new collaborative project to address big data and move precision agriculture to 'decision agriculture'. Titled *Accelerating Precision Agriculture to Decision Agriculture* the new cross-industry project involves 15 RDCs as part of the Australian Government's Rural R&D for Profit programme.

"There are so many grey areas when it comes to big data: who owns it; who can use it and how to best leverage the plethora of information already researched/generated as well as what is being generated on a daily basis," Jane said.

"From our perspective, in relation to the huge amount of research and information CRDC has generated with its research partners we need to be aware of who will hold the data produced and how access to that data will be controlled; the need to have commonality and portability of data sets; and demonstrated business cases and value propositions for cross-industry collaboration and the application of big data in agriculture."

Jane says based on the calibre and enthusiasm of the GrowAg participants, and with targeted, innovative research, agriculture is well placed to take advantage of any major disruptions involved with the evolution and use of big data.

"I was really pleased to see how engaged the GrowAg participants were in the big data and analytics space," Jane said.

"I saw a lot of future entrepreneurs in the room who were looking for ways and ideas to find these niches for data-driven services and get on board the decision agriculture train.

"Through our investments we aim to take advantage of the disruption big data is feted to bring to agriculture and break down any barriers to entry for young people in the industry to get involved in this space now, so we are ready for the future."

Leading from the front

CRDC is proud to partner with Auscott Ltd and Cotton Australia to sponsor enthusiastic and capable people from the industry to enter the Australian Rural Leadership Program (ARLP).

Run by the Australian Rural Leadership Foundation, the experience always receives fantastic reviews from participants, with recent cotton-industry graduates Jamie Iker and Sean Boland no exception.

Jamie is an agronomist with Spackman Iker in Emerald, Central Queensland and has been involved in the industry in many avenues, as part of on-farm research trials, an Australian Future Cotton Leader participant and was named Young Achiever of the Year at the 2012 Cotton Industry Awards.

"The most enjoyable part of the journey is difficult to pin down, the Kimberley experiential experience is certainly hard to beat," Jamie says.

"However on a higher level, the relationships that have been built over the past 18 months are priceless."

From a career or professional perspective, for Jamie the program has been excellent for helping develop leadership skills and processes that he says he would have otherwise not been exposed to.

"It has been fantastic to receive skills training and insights into various industries from the leaders in those industries. Being able to have a conversation with politicians, media presenters and journalists right through to people who are social entrepreneurs.

"Every person had a different view on what leadership looked like and what it took to get there.

"Being exposed to this range of leaders and engaging in conversation with them allows for a broader mindset when it comes to leadership which is critical, I believe, to becoming an effective leader.

"From a personal level, I have forged relationships and friendships that will last a lifetime and a belief and understanding of myself that could only have occurred through this process.

MELANIE JENSON

ABOVE: Sean Boland says the places he visited and the people he met were a highlight of the ARLP.

RIGHT: Jamie Iker. "Every person had a different view on what leadership looked like and what it took to get there."

"I greatly appreciate the opportunity that has been given to me by Auscott, Cotton Australia and CRDC to sponsor my position through this course."

Sean Boland is the manager of Auscott 'Midkin' at Moree. He says the highlight of the course was the overseas study tour to Indonesia.

"Through the organised itinerary we were able to meet with people and visit places that you wouldn't have seen if you'd arranged to go there yourself," he said.

"One of the great things about the program is that it brings together a broad range of people from a wide range of industries which gives exposure to a diverse range of viewpoints and has really given me a greater understanding and appreciation of different perspectives and views.

"Going forward, this helps to improve the decisions I make – you become better informed through different experiences, gaining more information and knowledge that is available to take forward with you into the future and I'd like to thank our sponsors for that."

PAUL GRUNDY

The current cotton industry participants are Matt Bradd, a cotton merchant with ECOM Commodities, and Meagan Laidlaw, a marketing services manager with Olam Queensland Cotton. *Spotlight* will be catching up with them soon to share their ARLP experience.

For more
w www.rural-leaders.com.au

IMAGE: MELANIE JENSON

Continuing our investment in world-leading cotton RD&E

In 2015-16, CRDC invested $21 million into cotton RD&E on behalf of Australia's cotton growers and the Australian Government – continuing our long-standing commitment to delivering real outcomes for growers and enhancing the industry's performance.

We invested into 290 RD&E projects across five key program areas (farmers, industry, customers, people and performance) during this year, working collaboratively with researcher partners and growers.

In this special *Spotlight* feature, we take a look at some of the highlights of the 2015-16 year.

You can find more detail in our *2015-16 Annual Report* which will soon be available from the publications section of our website: www.crdc.com.au/publications. You can also find a full list of our current research projects online at www.crdc.com.au/research-development.

IMAGE: MELANIE JENSON

Year in review: CRDC RD&E achievements 2015-16

The future of cotton irrigation – irrigation automation

The CRDC-led *Smarter Irrigation for Profit* project is a large-scale, ambitious project designed to achieve a 10 to 20 percent improvement in water productivity, efficiency and farmer profitability across the cotton, dairy, rice and sugar industries. Within cotton, one of the major focuses is irrigation automation and in 2015-16 CRDC supported the CottonInfo Irrigation Automation Tour, which took 40 cotton growers to the southern irrigation industry to see surface irrigation automation technologies in action. Participants of the tour were impressed with the technology; 95 percent said they would do something differently on-farm as a result of what they had learned on the tour.

Taking research to the field: nutrition researchers tour

The CRDC-supported CottonInfo nutrition tour delivered a series of five nutrition field days to growers across five cotton-growing valleys in February 2016, taking the latest developments in nutrition research to 360 cotton growers and consultants. The tour involved 10 leading CRDC-supported industry researchers who presented on and discussed a range of important cotton nutrition topics, helping growers realise optimal yields and fibre quality, reduce costs and emissions, and increase margins. The tour resulted in a 35 percent increase in understanding of soil health and nitrogen use efficiency among attendees and a 52 percent increase in understanding of loss pathways and greenhouse gas emissions.

World's first facility into cotton climate change research

In a first for the cotton industry globally, a national facility for cotton climate change research has been co-established by CRDC and CSIRO at the Australian Cotton Research Institute (ACRI) near Narrabri to investigate the impact of climate change on cotton production, and evaluate the likely effectiveness of adaptation strategies. Over three cotton growing seasons, CSIRO will be measuring cotton growth, production and resource use efficiency in detail, with new in-field poly-tunnels established at ACRI maintaining elevated CO_2, temperature and variable soil water availability.

Cotton Rivercare Champion demonstrates river stewardship

To demonstrate the best practice management of rivers and riparian areas, CRDC has appointed cotton grower Mark Palfreyman as the Cotton Rivercare Champion under the National Cotton Rivercare Champion project. As the champion Mark will demonstrate to cotton growers and the general public how best management practice maintains and/or improves the good condition of riparian areas. Under the program, long-term monitoring sites are being established on the Palfreyman family farm to look at water quality, the condition of native vegetation and the diversity of local fauna with results shared in real time via social media.

CRDC commissions first-ever resilience assessment

CRDC commissioned the Australian cotton industry's first resilience assessment to better understand how to help the industry best adapt to change and to identify critical threats and opportunities for future investment. The assessment looked at three levels of cotton production: the farm, the region and the whole of industry. It found that there are key drivers and shocks acting across the industry, and that industry leaders and growers need to be aware of the impact of those drivers and of the changing nature, frequency or severity of shocks to better prepare and respond to them.

Can cotton be used for 3D printing?

The CRDC-supported *Cotton rapid customisation feasibility study* conducted by QUT aimed to assess the feasibility of using cotton as a feedstock in rapid customisation processes such as 3D printing. The project identified areas within the broad range of rapid customisations where cotton has a clear advantage due to its inherent material qualities. The project found five areas for future research and investigation: on-site fabrication of cotton-based filtration products; on-demand manufacture of bespoke furniture; next generation lifestyle garments and accessories; 3D printing of children's toys; and patient-specific smart wound dressings using cotton-derived cellulose and rapid customisation.

CRDC supports new cotton innovation: ever-dry self-cooling fabric

The CRDC-supported, Deakin University-led *Ever-dry self-cooling cotton fabrics* project has successfully developed a new coating technique that gives cotton fabrics added functionality: the ability to regulate moisture, breathability and surface temperature. This important innovation has the potential to considerably increase the use of cotton in clothing ranges, including sportswear, summer clothing and defence force uniforms. Work is now underway on the development of a commercialisation plan.

Cotton's first Workforce Development Strategy

CRDC and Cotton Australia collaborated to deliver the industry's first *Workforce Development Strategy*. The strategy is focused on delivering workforce outcomes for growers on farm, and ultimately will

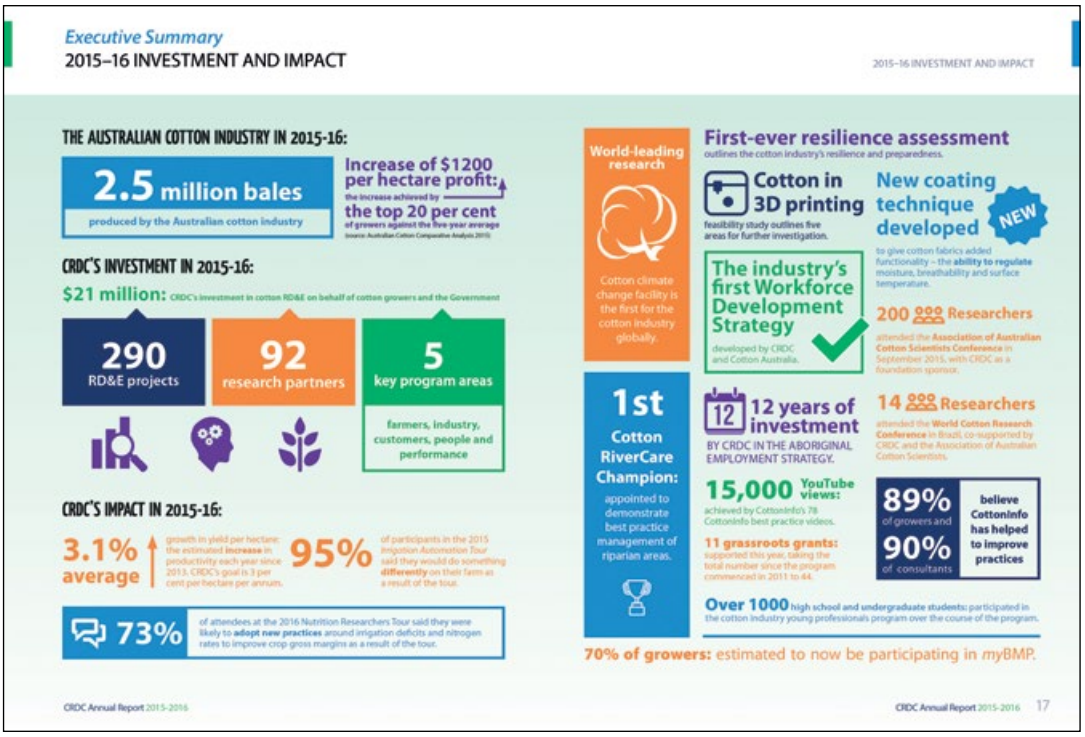

IMAGE: MELANIE JENSON

ensure that the cotton industry is able to attract, retain and develop people that will drive industry competitiveness. The strategy provides a shared and focused plan to ensure cotton industry organisations' investments in workforce target key priorities are well coordinated and deliver maximum outcomes.

Demonstrating best practice in cotton production

The CRDC-supported *Australian cotton production and best practice documentaries* project, delivered by QDAF, aims to communicate scientifically based crop production, protection and best practice principles to a diverse audience through a series of short, easily accessible videos. To date, 85 short videos have been produced, ranging from pre-season planter maintenance and planting tips through to overcoming challenges for new growers in the southern districts. The videos, which are published on the CottonInfo youtube channel, have collectively received 15,000 views.

Year in review: CRDC organisational highlights 2015-16

25 years of cotton RD&E led by CRDC

October 2015 marked 25 years of CRDC: 25 years of cotton RD&E, invested in by cotton growers and the Australian Government and led by CRDC. The milestone was marked through the release of a special edition of the CRDC *Spotlight* magazine, and a subsequent publication *CRDC: 25 years of RD&E*, which outlined the 25 key RD&E achievements in the cotton industry over 25 years.

20 years of GM cotton: CRDC R&D underpins stewardship

With the introduction of the industry's first Bt cotton Ingard in 1996, in 2016 the industry marked 20 years of GM cotton in Australia. CRDC has played an instrumental role in ensuring the enduring efficiency

of GM cotton through stewardship. Australia is now recognised as having the most pre-emptive, rigorous and successful resistance management system for transgenic cotton in the world.

Strong support for CRDC investments among growers

For the first time in 2015-16, the Grower Practices Survey sought feedback from growers about their perceptions of CRDC and support for our RD&E investments. The survey found that 99.6 per cent of growers are aware of CRDC, 88 per cent of growers are supportive of CRDC's research and investments, and 74 per cent of growers have input into CRDC about research.

Final RD&E reports now on-line

Over 1100 final reports of RD&E projects invested in by CRDC are now available via the CRDC online library, Inside Cotton. The reports range from 1986 to 2015, including those invested in by CRDC's predecessor, the Cotton Research Council. The reports join a host of other important cotton industry materials on Inside Cotton, including previous editions of the CRDC *Spotlight* magazine, CRDC corporate publications, papers and presentations from the Australian Cotton Conferences and archived materials from the former cotton CRCs.

Second annual Strategy Forum identifies cotton RD&E priorities

CRDC hosted its second annual Strategy Forum in Brisbane in May 2016, bringing together cotton growers on Cotton Australia's grower advisory panels to help determine the industry's future research priorities. The Forum is part of CRDC's procurement process, which was revised in 2015-16 to improve efficiency, streamline the RD&E investment process and provide greater clarity to researchers.

Collaboration: a key to cotton RD&E

CRDC works in partnership with other industry bodies and other rural research and development corporations (RDCs) to achieve strategic outcomes for the industry, and to leverage higher returns for our investments. This underpins our investment strategy, with CRDC partnering in over 80 percent of RD&E projects conducted in the cotton sector. Almost 25 percent of CRDC investments are in cross-sectoral RD&E. The collaboration extends from national to cotton industry-specific and local initiatives – from national cross-sectorial partnerships on water and soils; to the industry-specific extension joint venture, CottonInfo; and at the local level, partnerships with Cotton Grower Associations on CRDC Grassroots Grants.

Commitment to sustainability: response to the Third Environmental Assessment

The Australian cotton industry has a 24-year history of independent environmental assessments, demonstrating our commitment to monitoring and improving our environmental performance. In 2012, the *Third Environmental Assessment* was conducted and in February 2016, CRDC and Cotton Australia officially responded, outlining the high-level outcomes that have been delivered on behalf of the industry. These outcomes include the *Australian Grown Cotton Sustainability Report* and the establishment of 45 key sustainability indicators.

Cotton Futures: investing in blue-sky, transformational cotton RD&E

Cotton Futures provide a clear framework for CRDC to invest in long-term, transformational innovations to ensure the industry remains profitable, sustainable and competitive in the future. In 2015-16, CRDC invested in 11 innovative blue-sky projects under the three Cotton Futures themes.

CottonInfo: three years of connecting growers with CRDC-led R&D

CottonInfo marked three years as the industry's joint extension program in 2015-16, supported by CRDC, Cotton Australia and CSD Ltd. Studies conducted in 2014-15 have shown that 82 percent of growers and 90 percent of consultants are aware of CottonInfo; 78 percent of growers and 90 percent of consultants source information from CottonInfo; and 89 percent of growers and 90 percent of consultants believe CottonInfo has helped improve practices.

CRDC Deputy Chair awarded major industry award

CRDC Deputy Chair and St George cotton grower Cleave Rogan was awarded the prestigious 2015 Incitec Pivot Service to Industry Award at the Cotton Industry Awards presentation in August 2015. Cleave has grown cotton for more than 30 years, and is passionate about RD&E, having served as a director on the CRDC Board since 2011.

For more information on all of these achievements and highlights, download your copy of our (soon-to-be-available) 2015-16 Annual Report or the Annual Report Grower Summary from www.crdc.com.au/publications.

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