Taking cotton research to new heights

UNE Armidale 28-30 October 2019

CONFERENCE PROGRAM & ABSTRACT BOOK

AACS 2019 AUSTRALIAN COTTON RESEARCH CONFERENCE
#AACS2019

The conference organising committee gratefully acknowledges the generous support provided by the following sponsors and supporters

Gold

Silver

Bronze

Contents

Welcome on Behalf of the Conference Organising Committee

On behalf of the Conference Organising Committee and the University of New England, it gives me great pleasure to welcome you to Armidale, New South Wales, Australia and UNE for the fourth AACS conference. Given Armidale is Australia's highest city, with not one, but two cathedrals, it seemed fitting that the strap line for this conference was '*taking cotton research to new heights*'. Whether we achieve this will be down to you, but hopefully we've put everything in place to allow you to communicate your science, establish and build your research networks and do so in a fun environment. In delivering this conference, we've kept with the AACS philosophy of giving everyone who wants to talk a chance to do so. This does come at a cost, in terms of concurrent sessions, but hopefully you will find the short distances between the lecture rooms allows you to make it to the talks that interest you.

Now, before I go any further, I need to thank our sponsors: CRDC, CSIRO, CSD, UNE, Bayer and NSW DPI. Without their support, and the assistance of the AACS committee, we simply would not have a conference. I also want to acknowledge the Conference Organising Committee who have kept me sane, lightened the load, problem solved and created, and turned up to numerous meetings over the last two years to keep things on track. To you all, thank you.

So what have you let yourself in for? Over the last three conferences the feedback has captured that people want some form of training at these conferences. So, to meet your desires we'll close the conference with a workshop, led by renowned science communication expert Michael Mills. We've fought to bring this to you because in an age when you no longer need to be an expert to have an opinion, it becomes even more important to teach us, the experts, how to share our stories and opinions with the world in ways that delivers truth, meaning and impact.

Our stories, and how we tell them, have never been more important. Once again, the Australian cotton industry is being judged and our social license to grow cotton is being scrutinised. Drought awareness and water use are the current areas where opinions often outweigh facts, so it remains, largely up to us, to help correct these perceptions. In the meantime, the drought imposed reduction on cotton production, and agriculture in general, has massive effects on the local rural communities in which many of us live. The AACS recognises both this and that a downturn in our agriculture directly affects us, the researchers who support it. Less crops means less funding, which means fewer jobs. This can have a significant effect on workforce mental health, which is why we will start the conference exploring ways to recognise and cope under these difficult times. Once armed with this, it will be over to you to start telling us your stories.

I'm looking forward to hearing as many of these stories as I can, to meeting some of you for the first time and to catching up with those of you I have known for a while. So, prep those slides, practice those talks, travel safely and we'll see you in Armidale.

Enjoy the conference!

Dr Oliver Knox

Chair, Conference Organising Committee

Welcome on behalf of the Association of Australian Cotton Scientists

Welcome to our fourth Cotton Research Conference and what promises to be another diverse and busy program with over 110 speakers presenting their research and ideas for discussion.

The last 12 months have been challenging both for our industry and many people personally due to the drought, funding challenges and a changing public discourse regarding the role of cotton production and agriculture more generally within Australia. So I would really like to encourage you to use the next three days to take a break from your everyday business and immerse yourself in the conference program. We have an opportunity to engage with each other, discuss ideas and go forward from the conference with a sense of renewed purpose for the important work that we do.

I would like to thank Oliver and his team for their efforts in pulling together this event. This year the committee have put together a program that enables our members to share and discuss ideas but also aims to tackle some broader challenges around the communication of science with the wider community and mental health – reflecting the more challenging environment that many of us have encountered recently.

A core mission for our Association is to provide a representative body to promote and enhance cotton research; facilitate communication, the exchange of ideas and collaboration between our members; and to act as a point of contact between scientists, the cotton industry and the International Cotton Researchers' Association. Please take the opportunity to participate in our AGM on the last morning of the conference where we will discuss business for the Association going forward and vote for our representatives for the coming two years.

Kind regards,

Paul Grundy

AACS Chairperson

Conference Organising Committee, 2019

Oliver Knox – Chair of Conference Organising Committee

Rhiannon Smith – Deputy Chair and Science Program Coordinator

Yui Osanai – Secretary

Guna Nachimuthu – Treasurer

Katherine Polain – Registration Desk, Workshops and Volunteer Coordinator

Sharon Downes – Social Program Coordinator

Sharna Holman – Social Media, Website and Mentoring Program Organiser

Warren Conaty, Gupta Vadukattu and Philippe Moncuquet – Trivia and People Bingo Coordinators

Kristen Knight, Susan Maas, Brendan Griffiths – Other Committee Members

Mary Whitehouse – Chief Devil, Devil's Advocate Coordinator

Conference Program – Overview

The program includes 3 days of plenary presentations, themed symposia and associated scene-setting keynote presentations, workshops and social networking events. The program has been designed to balance plenary presentations of relevance to a broad audience, keynote presentations with considerable detail relevant to individual symposia, and research presentations of varying duration to showcase the breadth of research occurring in our industry. A panel discussion session on the future of agriculture will take place with audience participation following on from a variety of thought-provoking presentations. Workshops will delve into social issues associated with researcher health and wellbeing, and communication with a variety of audiences. Social networking events designed to build new and strengthen old friendships have been dotted throughout the program. AACS awards will be presented during the conference dinner and are designed to celebrate the contribution of scientists in the Australian cotton industry.

Conference Dates:	Sunday 27th– Thursday 31st October
Welcome BBQ:	Sunday 27th October
Cotton Industry 101:	Monday 28th October
Health and Wellbeing Workshop:	Monday 28th October
Devil's Advocate:	Monday 28th October
Future of Agriculture Panel discussion:	Tuesday 29th October
Conference Dinner:	Tuesday 29th October
AACS Annual General Meeting (AGM):	Wednesday 30th October
Science Communication and Extension Workshop:	Wednesday 30th October
Science Communication Workshop for Postgraduate Students:	Thursday 31st October

Plenary Speakers

Ian Taylor, Cotton Research and Development Corporation, Narrabri	A Researcher's Odyssey
Paxton Payton, USDA-ARS Cropping Systems Research Laboratory, Lubbock, Texas, USA	Challenges in Genetic Improvement of Abiotic Stress Tolerance: The Ups and Downs (Mostly Downs) of Candidate Gene and Pathway Approach
Guna Nachimuthu, NSW Department of Primary Industries, Narrabri	On-farm and Off-farm Sustainability: Everything You Don't Want to Hear from a Fibre Refugee
Mike Logan, Oakville Pastoral Co Pty Ltd	How to Have Science Lead Practice and Behaviour Change in Rural Industry
Allan Williams, Cotton Research and Development Corporation, Narrabri	The Footprint of Fashion: Can Cotton Tread Lightly in a Circular Economy
Rhiannon Smith, University of New England, Armidale	Cotton Doesn't Grow on Trees, But Ecosystem Services Do!

Symposia and Keynote Speakers

Weeds **Rick Horbury**, Bayer CropScience	Using Innovation to Manage Difficult to Control Weeds in the Australian Cotton System
Soils – **Gupta Vadakattu**, CSIRO	Harnessing Beneficial Microbes in Cotton Systems
Entomology – **Hazel Parry**, CSIRO	Computer Simulation Models as Tools for Informing Insect Management
Water Management – **Allison McCarthy**, USQ	In-season Yield Prediction using VARIwise
Fibre Quality – **Stuart Gordon** and **Rose Brodrick**, CSIRO	A Comparative Analysis of Cotton and Hemp Production in Australia
Breeding – **Warwick Stiller**, CSIRO	Breeding, Traits and Future: Perspectives from an Optimistic Pessimist
Ag Tech (no keynote)	N/A
Pathology – **Duy Le**, NSW DPI	Alternaria Leaf Spot of Cotton: A Re-emerging Disease Associated with a New Pathogen
Physiology – **Katie Broughton**, CSIRO	Climate Change, Climate Variability and Extreme Weather Events! How Might These Impact Australian Cotton Systems
Natural Resource Management **Mick Rose**, NSW DPI	Quantifying the Potential Environmental Risk of Pesticides used on Cotton Farms
Extension, Engagement and Capacity (no keynote)	N/A

Workshops

Researcher Health and Wellbeing (Monday 28th October)

When someone tells you to just "pull your (cotton) socks up", it's not always that easy and you may want to tell that person to just "put a (cotton) sock in it". This workshop will introduce you to some take-away wellbeing ideas from ACT or Acceptance and Commitment Therapy that promote resilience and compassion for self and others. It will also look at the important role that animals play in our lives and how animal-assisted therapy can enhance wellbeing.

Science Communication and Extension (Wednesday 30th October)

We are living in a world in which we are poorly adapted to manage the amount of information, and to be able to discern truths from untruths. We are living at a time where many of the adaptations that have served us well for millennia, are making it impossible, at times, to make sense of an ocean of information in which we can barely keep our heads above water. But there is a way to break though the noise. What defines us as a species more than anything, is that we are storytellers. We are *Pan narrans*, the storytelling chimp; we are certainly not *Homo sapiens*, (wise man). In a thought-proving presentation, Michael Mills will challenge us to the core and demand that we rethink how we communicate science to the public. In so doing, we will be asked to return to understanding and utilising the only thing that has really ever worked: story.

Social and Networking Events

Sunday Conference Mixer
Sunday 27 October, 5.30 pm–9.00 pm
Armidale Bowling Club
92–96 Dumaresq Street, Armidale

Take the opportunity to enjoy a BBQ dinner and drinks while catching up with old and new colleagues and friends. We will also be having the bowling green available so you can show how transferrable research skills can be with barefoot lawn bowls. While at the Conference Mixer, take the chance to skip the morning crowds with the registration desk being open and available on the night.

Cotton Industry 101 for new students and researchers
Monday 28 October, 1.00 pm (lunch)
Red Lab, UNE campus

Are you a new student or research? Do you know 'who's who in the zoo'? Come along to our interactive Cotton Industry 101 session where different industry organisations' roles and linkages are explained. Lunch will be provided in the room.

Devil's Advocate
Monday 28 October, 5.30 pm–6.30 pm
Oorala Centre, UNE Campus

The Devil's Advocate session encourage delegates as a group to freely discuss points of interest.

The session starts with some wine. The Devils will take it in turn to express an opinion (possibly counter to their own) on an idea or theory from the day that is controversial or of interest. Delegates are invited to counter this perspective and potentially highlight or challenge some of the ideas and theories generated from talks during that day.

The session is managed by a Chief Devil who will make sure that no delegate (or devil) talks for too long or too often, and that everybody 'plays the ball, not the player'. At the end of the session, the adjudicator summaries the day's events.

Conference Dinner
Tuesday 29 October, 6.30 pm–late
Armidale Bowling Club
92–96 Dumaresq Street, Armidale

The conference's celebratory dinner will be a night of fun with great food and drinks, awards, trivia and music.

Dress: Smart casual

AACS Annual General Meeting

Wednesday 30th October, 8.00 am
Belshaw Lecture Theatre

The Annual General Meeting of the Association of Australian Cotton Scientists will be held on Wednesday morning at 8 am in the Belshaw Lecture Theatre. Please come along and support the Association. Discussion will be on the business for the Association going forward and voting representatives for the coming two years.

Conference Day 1 – Sunday 27th October

5.30–9.00 pm	Barefoot Bowls and BBQ, reception desk open (Armidale Bowling Club)

Conference Day 2 – Monday 28th October

8.00 am	Registration and Speakers' desks open, welcome cuppa, etc.		
9.30 am	Welcome to Country (Belshaw Lecture Theatre) Welcome to UNE Conference Opening		
10.30 am	Plenary: Ian Taylor (Belshaw Lecture Theatre)		
11.00 am	Morning Tea (Dillon Corridor)		
Location	**Lecture Theatre 3**	**Dillon Lecture Theatre**	**Belshaw Lecture Theatre**
11.30 am	**Weeds**	**Soils**	**Entomology**
1.00 pm	Lunch (Dillon Corridor) and 'Cotton Industry 101 for new students and researchers' (Red Lab)		
1.45 pm	**Water Management**	**Soils cont.**	**Entomology cont.**
3.45 pm	Afternoon Tea (Dillon Corridor) and Blue Tree Painting		
4.15 pm	Health and Wellbeing (Belshaw Lecture Theatre)		
5.15 pm	Day 2 closes		
5.30 pm	Devil's Advocate Session (Oorala Centre)		

Conference Day 3 – Tuesday 29th October

8.00 am	Registration and Speakers' desks open, welcome cuppa, etc.		
9.00 am	Housekeeping announcements (Belshaw Lecture Theatre) Plenary: Paxton Payton Plenary: Guna Nachimuthu		
10.30 am	Morning Tea (Dillon Corridor)		
Location	**Lecture Theatre 3**	**Dillon Lecture Theatre**	**Belshaw Lecture Theatre**
11.30 am	Fibre Quality and Processing	Breeding/Genetics	Ag Tech
1.15 pm	Lunch (Dillon Corridor)		
2.00 pm	**The Future of Agriculture (Belshaw Lecture Theatre)** Plenary: Mike Logan Plenary: Allan Williams		
4.00 pm	Afternoon Tea (Dillon Corridor)		
4.30 pm	Panel Discussion: Our Future (Belshaw Lecture Theatre)		
5.15 pm	Day 2 closes		
6.30 pm	Conference Dinner, Trivia and AACS Awards (Armidale Bowling Club)		

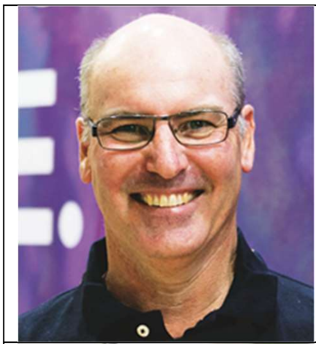
Conference Day 4 – Wednesday 30th October

8.00 am	Registration and Speakers' desks open, welcome cuppa, etc.		
8.00 am	AACS AGM (Belshaw Lecture Theatre)		
9.00 am	Housekeeping announcements (Belshaw Lecture Theatre) Plenary: Rhiannon Smith		
10.00 am	Morning Tea (Dillon Corridor)		
Location	**Lecture Theatre 3**	**Dillon Lecture Theatre**	**Belshaw Lecture Theatre**
10.30 am	Natural Resource Management	Pathology	Physiology
12.15 pm	Lunch (Dillon Corridor)		
2.00 pm	Extension, Engagement and Capacity	Pathology cont.	Physiology cont.
2.00 pm	Afternoon Tea (Dillon Corridor)		
2.30 pm	Science Communication and Extension Workshop (Belshaw Lecture Theatre)		
4.00 pm	Panel Discussion: Science Communication and Industry Advocacy		
4.30 pm	Conference Awards, Reflections and Final Thoughts		
5.00 pm	Conference Close		

Conference Day 5 – Thursday 31st October

9.00 am – 12.30 pm	FREE Science Communication Workshop (attendance requires RSVP) presented by Michael Mills, aka Professor Flint (EM1, Natural Resources Building)
9.00 am – 3.00 pm	FUSCOM (Belshaw Lecture Theatre)

Plenary and Keynote Speaker Biographies



Ian Taylor

Dr Ian Taylor has extensive experience across the cotton RD&E pipeline, having worked as a researcher specialising in integrated weed management before progressing to management positions within the cotton industry's extension program, CottonInfo and CRDC. Prior to being appointed Executive Director, Dr Taylor performed the role of CRDC's General Manager of R&D Investments for a period of five years, overseeing CRDC's investment in cotton RD&E to deliver impact and leading the development of the CRDC Strategic RD&E Plan 2018-2023.

Paxton Payton

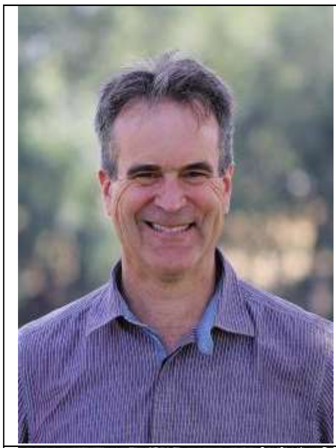
Dr Paxton Payton is a plant physiologist with a PhD in Biology from Texas Tech University. He joined the USDA-ARS Cropping Systems Research Lab in 2002 and is an Adjunct Professor in the Departments of Biology and Plant and Soil Sciences at Texas Tech. His primary research is aimed at understanding molecular and physiological factors that influence abiotic stress tolerance. Of particular interest is how plants acclimate to drought and temperature stress and the development of crop management tools that allow growers to monitor stress and take advantage of plant acclimation responses to maximise yields with limited inputs.

Guna Nachimuthu

Dr Guna Nachimuthu is a Research Scientist at NSW DPI, Narrabri. He graduated with a Bachelor of Science and Master of Science in Agriculture (Soil Science and Agricultural Chemistry) from Tamil Nadu Agricultural University, India. Guna's PhD from the University of New England quantified the P contribution of legume residues to subsequent corn. Guna leads a project that aims to minimise yield variability in cotton, and is involved in a range of projects encompassing soil productivity and sustainability in a cropping systems context. He was awarded the 2017 AACS Early Career Scientist Award.

Mike Logan

Mike Logan is the Director of the Oakville Pastoral Co Pty Ltd, the first company in the world to achieve ISO 14001 (Environmental Management Systems) certification back in 1997. Mike has extensive knowledge of both agricultural and environmental R&D. He was Chairman of the CRDC Board (2007–2013), CEO of Dairy Connect Ltd (2012–2016), Director of the Peter Cullen Trust (2008–2012), Director and Deputy Chairman of the CRC for Irrigation Futures (2003–2008), Chairman of the National Program for Sustainable Irrigation (2001–2004), Director of Land and Water Australia (1995–2001 and Director of the Australian Rural Leadership Foundation (1993–1997).



Allan Williams

Allan Williams has worked in the Australian and international cotton industries for the last 25 years. Before joining CRDC, Allan's roles included Senior Agronomic Advisor for the global Better Cotton Initiative, the Executive Officer for the ACGRA, the Executive Officer for Cotton Consultants Australia, and a lawyer for the firm Mallesons Stephen Jaques. During his time with ACGRA, Allan was responsible for the development of the BMP Program - the predecessor to myBMP. Since 2006, Allan has also held the position of Chair of the International Cotton Advisory Committee's (ICAC's) Expert Panel on the Social, Economic and Environmental Performance of Cotton.

Rhiannon Smith

Dr Rhiannon Smith completed a B. Nat Res at the University of New England, with her Honours project supported by a Cotton CRC summer scholarship investigating biodiversity associated with tree plantings on cotton farms. She then completed a PhD examining ecosystem services provided by native vegetation, including biodiversity conservation, carbon sequestration and erosion mitigation. Post-PhD, Rhiannon has investigated ecosystem service provision across the cotton industry, management of riparian zones to improve ecosystem health and function, and is currently exploring the use of new technologies such as drones to achieve cost-effective broadacre revegetation on cotton farms.

Rick Horbury

Rick joined Bayer CropScience in 2007, first with the Development team specialising in pre and post-emergent herbicides. Rick then moved into a technical field extension role working with growers, industry and researchers through trials and demonstrations across Western Australia demonstrating a range of herbicide, fungicide and insecticide innovations. Rick has moved out of a field trial role and has been guiding the Bayer Market Development trials team in Broadacre, cotton and horticulture. With Bayer and Monsanto coming together Rick now leads a team of 16 across Australia and New Zealand including the Locharba research station at Narrabri, bringing new cotton traits and crop protection products to market.

Gupta Vadakattu

Dr Gupta Vadakattu joined CSIRO in Canberra in 1989 following his PhD and postdoc studies at University of Saskatchewan in Canada. He worked with the CRC for Soil and Land Management (1993–98) on microbial-protozoan interactions and their effects on microbial diversity and biological functions and showed the significance of maintaining resilient biological functions including N supply and disease suppression in Mallee soils for sustainable production and environmental health. His research elucidated the exposure pathways for Bt-proteins with soil biota and contributed scientific evidence to the debate on benefits and risks from GM plants in Australian agriculture.

Hazel Parry

Dr Hazel Parry graduated from the University of Cambridge (BA Hons) and the University of Leeds (PhD) in the UK, studying Geography. She joined CSIRO in 2009, arriving as a postdoc and continuing her career with CSIRO to become a senior research scientist based in Brisbane. Her research seeks to gain knowledge on agricultural landscape features and environmental drivers that increase insect pest and disease vector outbreak risk, in relation to population dynamics and dispersal behaviours. This knowledge supports more cost-effective and efficient use of a range of insect pest management technologies: from pesticide to Bt and biocontrol.

Allison McCarthy

Dr Alison McCarthy is a Senior Research Fellow in mechatronic and irrigation engineering within the Centre for Agricultural Engineering at the USQ in Toowoomba. Her key research interests are improving water productivity using real-time, automated irrigation informed by sensors and data analytics, and reducing labour in crop scouting using crop monitoring machine vision systems. Alison was a co-recipient of the 2018 CSD Researcher of the Year Award, and received a 2015 Young Tall Poppy Queensland Award, two 2014 Science and Innovation Awards for Young People in Agriculture, Fisheries and Forestry, and a 2014 DSITI Early-Career Accelerate Fellowship.

Stuart Gordon

Dr Stuart Gordon is a Principal Research Scientist in CSIRO Agriculture and Food's Systems Program where he leads CSIRO's Advanced Natural Fibre Team. He holds wool and cotton classing certificates, a bachelor degree in Agricultural Science and a PhD from La Trobe University. He is also a graduate of the Australian Institute of Company Directors. Stuart has been involved in natural fibre research, manufacture and management for more than 25 years. He currently leads projects in fibre metrology, post-harvest processing and product development. He has been active in raising the profile of industrial hemp production and processing.

Rose Brodrick

Dr Rose Brodrick's research is focused on developing new technologies and integrated digital systems for the agricultural industry to improve farm productivity. Dr Brodrick has 19 years' experience working with irrigators (cotton, tomatoes, sugarcane) to develop management solutions in irrigated agriculture. Her research into crop physiology and agronomy has led to changes in production practices within the Australian Cotton Industry. Rose is currently a leader of the CSIRO's WaterWise Project that brings together a multi-disciplinary team that are developing digital solutions for precision irrigation in high value crops as part of the CSIRO's Digiscape Future Science Platform.

Warwick Stiller

Dr Warwick Stiller joined the CSIRO cotton breeding team in 1995 to do a PhD examining how to breed more water-use efficient cotton. Warwick has lead CSIRO's Cotton Breeding program since 2013 and delivered new varieties for all production systems and regions in Australia with higher yield, better disease resistance and fibre properties sought by spinners. His collaborative research efforts have seen Warwick investigate modern molecular tools for speeding up breeding and selection, collecting exotic cotton germplasm to ensure genetic diversity in breeding and discovering new sources of resistance to a range of important diseases.

Duy Le

Dr Duy Le completed his PhD, partly supported by the ginger industry, at the University of Queensland (UQ) in 2016 and followed by a year postdoc at UQ with support from the avocado industry. Duy joined NSW DPI in July 2017 as a cotton pathologist and currently coordinates a CRDC funded project to investigate novel solutions, including chemical and biological approaches, to manage some of the major disease of cotton such as Black root rot and Alternaria leaf spot. In addition to this project, he is involved in the National Disease Survey project led by DAF and with support from both these projects, coordinates a free diagnostic service for the cotton industry in NSW.

Katie Broughton

During her B. Agricultural Science at the University of Sydney, Dr Katie Broughton undertook a Cotton CRC Summer Scholarship Project with Dr Mary Whitehouse (CSIRO) researching the behaviour of mirids in response to their predators. She was then awarded a Cotton CRC Honours Scholarship Project with Dr Nilantha Hulugalle (NSW DPI) investigating root growth and turnover in Bt and non-Bt cotton. Katie completed a PhD on the integrated effects of warmer temperature and elevated CO_2 on early growth and physiology of cotton. Post-PhD, Katie has investigated the season-long effects of climate change on cotton growth and physiology, and is currently exploring management strategies for cotton grown in high input, high yielding cotton systems, to better understand the impact of a changing climate on the Australian Cotton Industry.

Mick Rose

Dr Mick Rose is interested in the interactions between plants, microorganisms and their environment, and how agronomic practices influence these interactions. Mick undertook his PhD at the University of Sydney through a Cotton CRC scholarship, exploring the role of wetland plants and microorganisms in improving water quality on cotton farms. Mick has since conducted research on plant growth-promoting biofertilisers in Vietnam, abiotic stress tolerance in rice in Japan and organic amendments for soil health and plant productivity in Victoria, Australia. Mick now works as a Research Scientist with NSW DPI, Wollongbar, on projects researching the impacts of pesticides on soil biology, crop health and the wider environment.

Workshop Presenter Biographies

	**Annette Stevenson** Annette Stevenson is Manager of UNE Student Counselling and Psychological Services (CAPS) which comprises a team of five other registered psychologists. Annette has been with CAPS since 1992 and became full time in 2004. She came to that role having coordinated the Armidale Sexual Assault Service for three years in the early 90's. Annette was also a supervisor within the former Armidale Child Sexual Assault Service for over ten years. She was Secretary of the Armidale Women's Shelter Management Committee for six years until the end of 2015. Prior to her work as a practicing psychologist, Annette worked in research, primarily in the road safety area with human factors psychologists and traffic engineers.
	**Gwen Shumack** Gwen Shumack has worked as a psychologist within UNE Student Counselling and Psychological Services (CAPS) for three years. Previously she worked as a psychologist for FaCS for nearly six years and worked with children and young people, foster carers, parents and prepared reports for the Children's Court. She covered rural and remote areas from Inverell, Moree, Glen Innes, Tenterfield and Tamworth. Since October 2018, Gwen has been accredited to deliver animal assisted therapy with her psychotherapy dog, Percy. This work involves using the human animal bond to develop emotional resilience, behavioural activation and relationship skills.
	**Mary O'Brien** Mary O'Brien was raised on the land and understands the diverse challenges faced by the rural sector. Since 1992, Mary has lived in the Darling Downs region of Queensland, where she has gained an in-depth knowledge of the local farming systems and built extensive networks throughout the Australian agricultural sector. Mary has worked in chemical use and best practice across most Queensland and New South Wales and with a range of agricultural industries. These include row cropping, horticulture, intensive animals, grazing, apiaries, viticulture, and aquaculture. Mary now works as a private consultant conducting spray application and drift management workshops around Australia. Mary is a myBMP accredited advisor.
	**Michael Mills/Professor Flint** Michael Mills is an award winning science communicator, writer, producer, and performer. He regularly produces experiences for cultural institutions, engaging communicates with the science and stories of their collections. As singing palaeontologist, Professor Flint, Michael has become a favourite in many Museums around Australia whenever there are stories to be told about the prehistoric past. Michael has written more than 50 shows and performed to hundreds of thousands of young people and adults over more than 20 years. He has worked in radio, wrote and performed the songs for the final year of Chanel 7's "The Book Place", and in recent years, has become a regular presenter at conferences.

Communicating Good Science Workshop (Thursday 31st October)

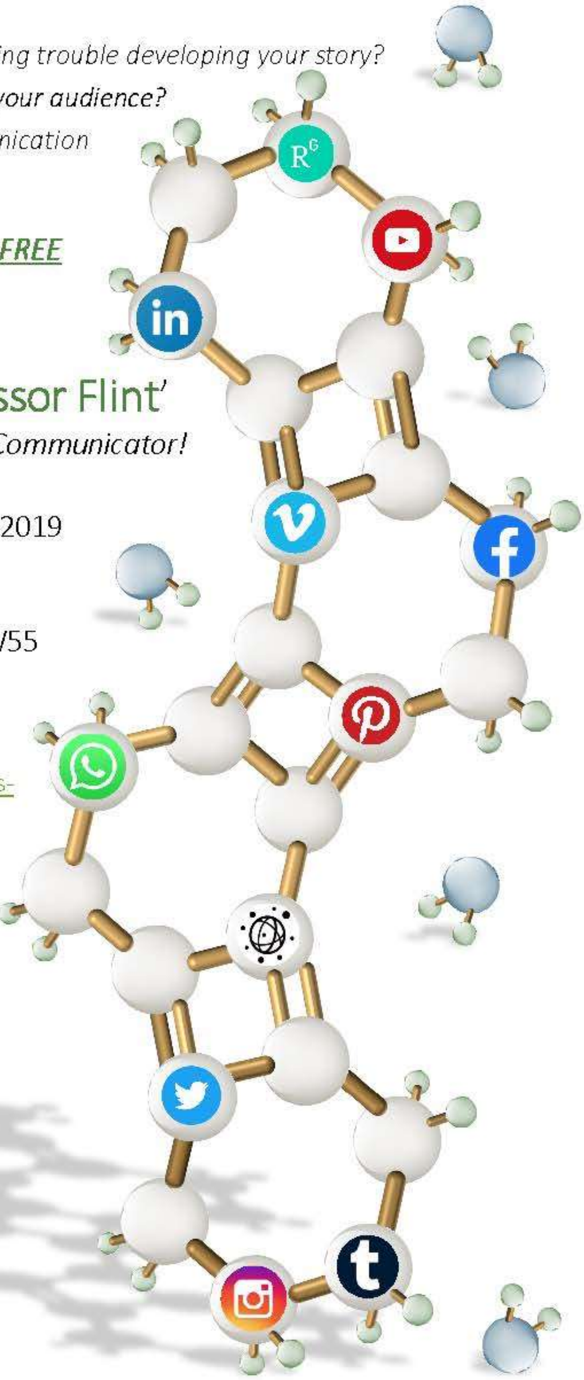
Once upon a time…

☑ *Tired of telling the same, boring story?* ☑ *Having trouble developing your story?*

☑ *Wanting to find exciting ways to engage with your audience?*

☑ *Are you a HDR student, ECR or science communication enthusiast?*

If you answered yes to any of these questions, this ***FREE*** *workshop is for* ***YOU!***



Presenting Michael Mills aka 'Professor Flint'

Australia's singing Palaeontologist & Science Communicator!

Date: Thursday, October 31st 2019

Time: 9am to 12.30pm

Venue: UNE Campus, EM1, W55

Register at:
https://www.eventbrite.com.au/e/hdr-ecr-communications-workshop-with-michael-mills-tickets-62615857716

This workshop will cover:

- ✓ Michael's journey as a science communicator
- ✓ Creating a story from data
- ✓ Key concepts in framing narratives and the forms these narratives can take
- ✓ Cognitive bias
- ✓ Morning tea provided

This event is courtesy of:

AACS 2019 Australian Cotton Research Conference

une University of New England — Faculty of Science, Agriculture, Business and Law

GRS Faculty of Science, Agriculture, Business and Law Graduate Research School

For further information, contact Katherine Polain (kpolain2@une.edu.au)

Information for Presenters

1. The presentation screen resolution is 16:9 (widescreen)
2. We will use Windows PCs, not Mac for presentations. Please be prepared if you use a Mac. Personal computers cannot be used for presentations.
3. Presentations must be loaded at the speakers' desk at least 2 hours prior to the session commencing.
4. Session Chairs will strictly adhere to the following presentation times:
   - Plenary and keynote presentations are 30 minutes (20–25 minutes speaking, 5–10 minutes questions and changeover)
   - 15 min presentations are 15 minutes (12 minutes speaking, 3 minutes questions and changeover)
   - 5 minute presentations are strictly 3 minutes, with 2 minutes questions and changeover.

The speakers' desk will be located in Lecture Theatre 2 (next door to LT3). Please introduce yourself to your relevant Chair before the commencement of the session.

General information

The 2019 Australian Cotton Research Conference is being hosted by the University of New England (UNE). UNE offers more than 200 courses at undergraduate, postgraduate coursework and higher degree research levels with options to study online or on campus.

Conference sessions will be held in the Belshaw Lecture Theatre, Dillon Lecture Theatre and Lecture Theatre 3 on campus. The registration desk is located in the Belshaw Corridor.

Armidale, a leader in education and agricultural research, is situated in the heart of the New England Tablelands in northern New South Wales. A city of historical significance, Armidale boasts many fine architectural landmarks, including magnificent cathedrals, churches and buildings, complemented by colourful pubs, restaurants, coffee shops, bookshops and quality gift and clothing shops, clustered around the central mall.

Armidale is famous for its cosmopolitan atmosphere, and atmosphere that provides for a diverse and distinctive lifestyle and recreational opportunities.

Located 1000 m above sea level in northern New South Wales, and within comfortable driving distance of Sydney and Brisbane, Armidale summers are mild to warm, while winters are cool and crisp. The annual rainfall of 800 mm is evenly spread between summer and winter, and the temperate tablelands environment is predominantly dedicated to livestock grazing of native and sown pastures, with extensive native woodlands and forest, and World Heritage and wilderness national parks along the Great Eastern Escarpment within a half an hour to an hour's drive.

Tourist Information

The Tourism Information Centre is located at 82 Marsh Street, Armidale: 6770 3888.
http://www.armidaletourism.com.au

Transport and Car Parking

With the exception of university accommodation, there are no motels within easy strolling distance of the venue.

Car parking at University of New England has a daily cost. However, this cost has been waived if you park in the Western carpark (see previous map). The Western carpark is at the western end of the campus, beyond Agronomy (W23). Signs will be evident around the campus for the duration of the conference. Once in the carpark, it is a short 5 minute walk back to the conference location – in W040 and W042. These buildings are at the end of the short run road.

If you park in the carpark near the conference location and do not buy a ticket you are likely to be booked and fined. In order to avoid the $120 fine, either please buy a parking ticket or use the free Western carpark.

We would like to encourage people to car pool where possible. A bus will be provided that will offer a limited (20–30 seats) pickup around town. Please consult the registration desk for more details and to book a seat on this service.

A bus service runs between the UNE campus, colleges and the town centre at approximately 15 min intervals during the day, with pick up points located on the campus ring road. View Edwards' public bus service schedules at: https://www.edwardscoaches.com.au/timetables.html

Armidale Taxis can be contacted on 131 008 or 6771 1455.

Emergency Situations

UNE Safety and Security: 6773 2099

New England Ambulance Service: 6771 1710

Armidale Fire Station: 6771 5076

Armidale Police Station: 6771 5076

Banks and ATMs

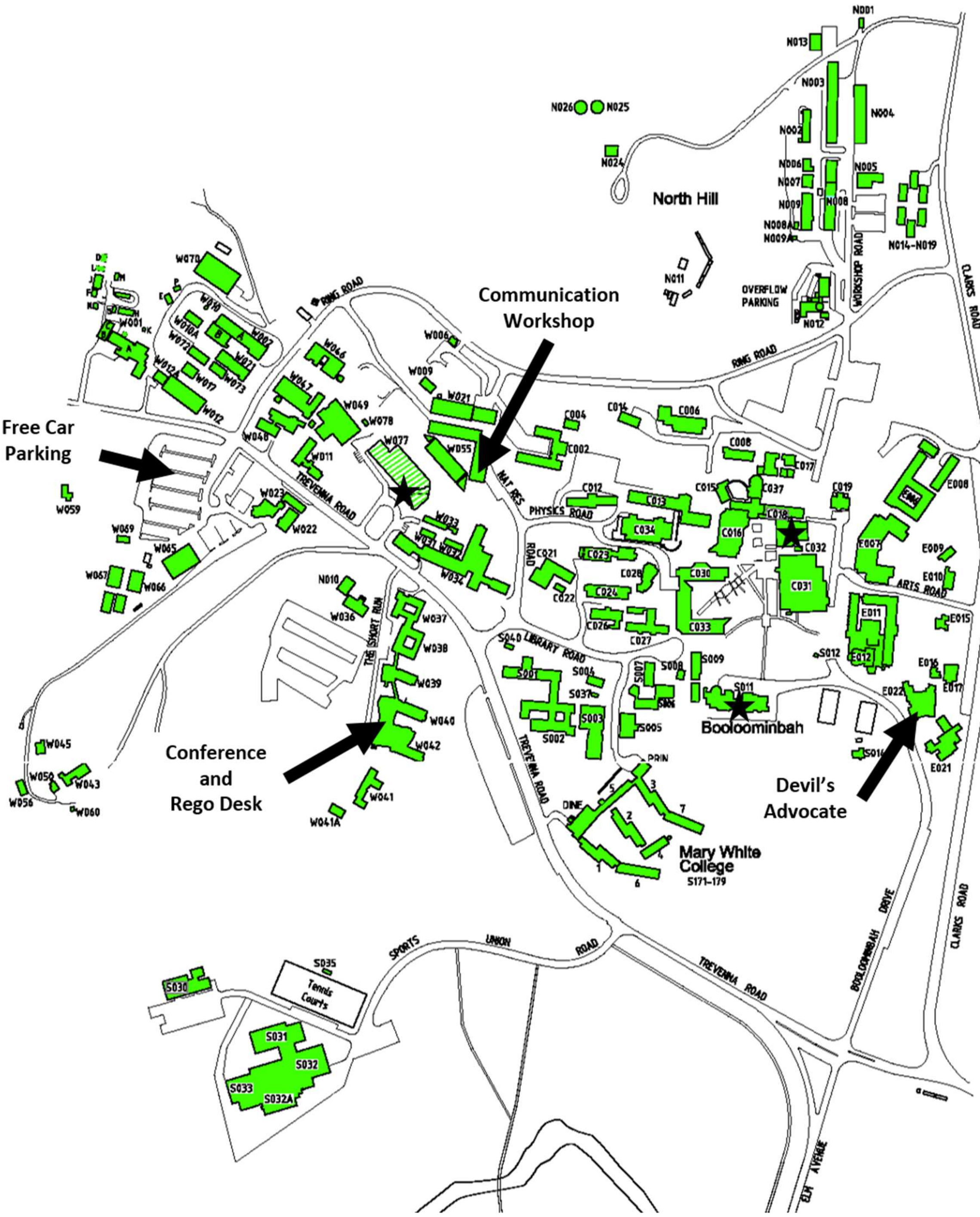
Major banks are located in the town centre, while an atm is located in the northeast quadrant of the campus (near the UNElife café).

SportUNE

Delegates will be granted access to SportUNE facilities (https://sportune.com.au/) during the conference. Please enquire at the Registration Desk should you require access.

UNE Campus Map

Note, there are cafés at W077, Booloominbah and C018 (see star symbols below)



Abstracts

Effect of nearby woody vegetation and contrasting insecticide regimes on invertebrates in irrigated cotton crops

Karrar Al-Hajiya, Nick Reid, Rhiannon Smith, and Nancy A. Schellhorn

Farm and landscape management is important for achieving optimum benefits from biological control and sustainable pest control in intensive cropping systems. Despite some research has been conducted on pest and beneficial interactions in landscape context, landscape context has been assumed capable of reducing pest outbreaks in monocultures. However, landscape context and farming practices are recognised as having a major impact on pest and beneficial invertebrate abundance. To investigate such regulation, we sampled the major pest and beneficial invertebrate taxa in different habitats (river red gum and poplar box woodland, weedy grassland, irrigated cotton and refuge crops) with cotton crops stratified by the distance to and amount of nearby woody native vegetation. We also sampled two different types of farm that varied in their approach to the use of insecticide to control pest invertebrates in crops (low-insecticide management vs conventional management reliant on insecticide). Crops with a high amount of woody native vegetation nearby on low-insecticide managed farms exhibited lower pest abundance, higher beneficial invertebrate abundance and higher cotton yield than crops with less amount of woody native vegetation nearby on conventionally managed farms. In conclusion, maintenance of woody native vegetation near cotton crops combined with minimal use of insecticides offers real prospects for more sustainable, environmentally and economically acceptable in irrigated cotton crops.

Fate of glyphosate resistant *Echinochloa colona* in the presence and absence of glyphosate: toward more understanding of herbicide resistance

Md Asaduzzaman

Weed resistance to glyphosate is now a reality in the Australian cotton cropping system. Best management practices including knowledge about biology, ecology and the fate or fitness of suspected weed species can help towards overcoming herbicide resistance. This study identified phenotypic (susceptible S versus resistant R) lines (2B21-R, 2B21-S, 2B37-R and 2B37-S) from two glyphosate resistant populations (2B21 and 2B37) and evaluated their fitness for glyphosate. Three years of consecutive study revealed that glyphosate rates calculated to cause a 50% (ED50) plant mortality for the four phenotypes of two populations of *E. colona* are 1190, 250, 3900 and 217 g a.i. ha^{-1} of glyphosate for 2B21-R, 2B21-S, 2B37-R and 2B37-S respectively. There was a stimulation of biomass production in both S phenotypes and biomass accumulated was more for both S phenotypes than their R phenotypes due to the application of lower doses (34 and 100 g a.i. ha^{-1}) of glyphosate. The plants from R lines generated 30% and 37% fewer spikes than S plants in the absence or low doses (0 to 67.5 g a.i. ha^{-1}) of glyphosate and there was no spike formation in both S phenotypes after herbicide dose 540 g a.i. ha^{-1}. Both R phenotypes produced more spikes than S phenotypes at increased rates of glyphosate. The R lines produced double the number of seeds at each dose of glyphosate compared to the S phenotypes. These differences were significant, indicating that there is no cost of glyphosate resistance for spike production in the presence of glyphosate. The results of this study reveal that glyphosate resistant plants of *E. colona* grass will be less fit than susceptible plants (from same population) in the absence of glyphosate, additionally in the absence of glyphosate backward selection can occur. But in presence of glyphosate R plants may eventually dominate in the field.

Physiological response of cotton to nitrogen and irrigation management strategies

Jon Baird, Graeme Schwenke, Gunasekhar Nachimuthu, Ben Macdonald

Cotton productivity (lint and seed yield) has continued to improve in Australia over the last 40 years with benefits to the efficiency of water and nutrient use. However, recent industry trends show that yield improvement is not proportionate with the increasing nitrogen (N) application rate (industry mean = 335 kg N/ha (2018 CRDC Growers Survey) and the intensive irrigation management strategies. The balance between water and N availability on cotton growth dynamics is not well understood, as an excess or deficiency of either input can influence the impact of the other. Field investigations located within the Namoi Valley (Myall Vale, NSW) were conducted with various applications of N fertiliser and irrigation water in 2016–17 and 2017–18 cotton seasons. Fertiliser N rates included nil N, a budgeted optimum rate and a high rate (industry average). Application timing included 100% pre-plant, 100% in-crop and several pre-plant: in-crop ratios in between. Irrigation frequency was scheduled using soil water deficits of 50 mm and 70 mm from plant available water capacity (220 mm to 120 cm depth).
The high N fertiliser rates strongly influenced most of the measured plant growth parameters in both growing seasons, but not lint yields. High N application rates increased vegetative growth and biomass (shoot) production. The greater vegetative growth during the early fruiting stages led to reduced fruit retention on the lower branches. In 2016–17, plant height and node numbers were higher within the 50 mm deficit, high N application rate and earlier N timing treatments. Although there was no effect on total bolls, suggesting a higher percentage of fruit loss. Subsequently lint yields were unaffected.

Predicting Micronaire Accounting for Integrated Effects of Environment and Crop Growth

Michael Bange, Robert Long, Sarah Caton, and Nicolas Finger

Cotton fibre micronaire is an indirect measure of fibre linear density and maturity. Factors affecting supply and partitioning of assimilates to fruit affect micronaire. High micronaire occurs when there is an excess of assimilates due to good growing conditions and/or fruit number is low. Conversely low micronaire occurs when growing conditions are poor and/or fruit number is high. Little research has been conducted attempting to develop an integrated understanding at a canopy level of combinations of some of these impacts on micronaire. A range of field experiments were established to generate variability in measured micronaire for predictive function development (range 3.5 to 5.0). These experiments had treatments that: varied growing conditions of the cotton crop through changes in planting time; manipulated crop canopy size through use of plant growth regulators or the removal of plant terminal prior to flowering; and changed the demand by the fruit by manually removing a proportion of fruit from the plant. The ability of these functions were also tested against independent data gained from similar experiments conducted in subsequent years. A function that accounted for temperature effects during boll filling, leaf area index at flowering, and using final boll size was able to predict micronaire well (R^2 = 0.81) over existing prediction functions using temperature during boll filling alone (R^2 = 0.21). Independent validation of function was also able to predict micronaire well (R^2 = 0.62) for the predicted versus actual response. Using these functions the ability to predict micronaire could be used to refine management decisions to improve fibre quality or assist in its management at harvest. Additionally these functions are ideally suited to crop measurements taken with remote and proximal sensing technologies to improve precision of prediction.

Fitness, stability and diversity of indoxacarb resistance in Australian *Helicoverpa armigera*

Lisa Bird, Linda Drynan and Paul Walker

F2 screening has increased capacity to detect low frequency resistance and resulted in the first case of genetic indoxacarb resistance isolated from field *H. armigera* in Australia. Quantitative genetic analysis showed 200-fold resistance was conferred by an autosomal, partially dominant (DLC = 0.75) genetic factor. Inhibition studies concluded a metabolic mechanism later confirmed in genotype-by-sequencing analysis and was found to be associated with the CYP6AE gene cluster that encodes cytochrome P450 enzymes.

Fitness costs can be important for influencing resistance development. In early-stage resistance non-recessive costs expressed in rs individuals are more effective than recessive costs expressed only in relatively rare rr individuals. In the absence of insecticides non-recessive costs confer higher fitness in ss compared with rs, which selects strongly against resistance.

Relative fitness of near-isogenic resistant, susceptible and F1 hybrid strains was determined from life-history trait analyses. There were no major costs associated with survival, development or female reproductive potential in resistant strains. Although reproductive capacity was reduced in resistant males, resistance was stable for six generations in the absence of selection. A 52% reduction in survival and reduced male pupal size in resistant insects following simulated diapause suggests reduced physiological capability of indoxacarb resistant *H. armigera* to withstand overwintering conditions, highlighting the importance of resistance management in regions where diapause doesn't occur.

A second unique indoxacarb resistant strain (UN1U3-10) was isolated in 2017. It demonstrated >700-fold resistance and high genetic dominance (DLC = 0.9) indicating indoxacarb resistance is genetically diverse in Australian *H. armigera*.

Soil water potential forecasting for cotton irrigation decision support

James Brinkhoff, John Hornbuckle, Carlos Ballester-Lurbe

We studied techniques to forecast soil water tension for cotton irrigation recommendation using in-field sensors, weather station data and remote sensing. Soil water tension is an attractive soil moisture alternative metric to the metric commonly used in cotton operations, volumetric water content. The sensors indicate the pressure plants need to apply to extract water from the soil, and does not need calibration in different soil types. Sensor and weather data was collected using our WiField nodes, and transmitted to a database on Google Cloud Platform (GCP). A number of learning methods (Lasso linear regression with regularisation, decision trees, random forest and support vector machine) were trialled to model soil water tension from past sensor values and crop evapotranspiration (computed from weather data derived reference evapotranspiration and remote sensed normalised difference vegetation index, NDVI). A model for each sensor location was continuously updated with new sensor data through the season, and the resulting model combined with automatically obtained weather forecast data to predict future soil water tension. The study was carried out on a cotton farm in 2018–2019, with the wireless soil moisture monitoring equipment deployed across five plots. An online irrigation dashboard was created showing previous and forecast soil moisture conditions, along with weather and NDVI. This provided growers and agronomists with an easy to use tool to guide decisions on water needs in the coming 7 days, taking into account current soil moisture conditions, per-plot cotton plant vigour and coming weather conditions.

KEYNOTE: Climate change, climate variability, and extreme weather events! How might these impact Australian cotton systems?

Katie Broughton, Michael Bange, Paxton Payton, David Tissue

Climate change may have significant impacts on the physiology and yield of cotton. Understanding the implications of integrated environmental impacts on Australian cotton systems is critical for developing management solutions that confer resilience to stress induced by climate change. Australian cotton systems are characterised by high input/high yielding intensively managed systems which may be strongly affected by highly variable and extreme climates. This study combined (1) an analysis of temperature trends throughout key Australian cotton regions, and (2) an investigation into the integrated effect of warmer temperature and elevated [CO_2] on physiology and growth of cotton grown in high-input field conditions. From 1957 to 2017, there was an increased accumulation of day degrees across important cotton regions, indicating long season temperature effects. Field studies found that cotton grown at warmer temperatures had greater vegetative-to-fruit biomass ratios than controls, but total biomass production did not differ. Thus, climate change will potentially cause significant rank growth, resulting in less yield and reduced water use efficiency. We are investigating whether the current recommendation for growth regulators to control excessive vegetative growth requires modification for future climates, and whether cultivars vary in response to these altered climatic scenarios.

A Weed "What, Where, How and Why" the new Noogoora burr story for cotton

Graham W. Charles, Stephen B. Johnson, James P. Hereward, David Gopurenko, Bruce A. Auld, Heather E. Smith, Karen A. Kirkby and Toni A. Chapman

The Noogoora burr complex (*Xanthium* sp.) are major summer-growing annual weeds of cropping and pastures in Australia and the US. In Australia four species are recognised in the complex. In a 2-year study we collected burrs from 115 populations from 82 sites in main-land Australia, showing that the distribution of these burrs has changed markedly since the previous survey in the 1990s. Using barcoding and next-generation sequencing, we were able to identify two genetically different clusters amongst the specimens, possibly two species, not the four species previously recognised, with strong evidence of hybridisation between the clusters. We were able to demonstrate a bioherbicide, using spores of *Alternaria zinniae* in a complex emulsion, was effective in controlling all types of this weed. We further examined the status of Noogoora burr as a host of the pathogen that causes Verticillium wilt in cotton, and found that all species were Vertilillium hosts, often with multiple wilt pathotypes identified in a single burr. In related research, we determined that high yielding cotton crops are very sensitive to competition from large weeds, such as Noogoora burr, with full season competition from even 1 burr plant per m of crop row able to reduce cotton yields by 89%. At 1 weed m^{-1}, the critical period for controlling these large weeds in cotton extends from crop emergence through to mid-season (836 degree days), much longer than has been previously reported.

Addressing Cotton Blue Disease in the US
Jenny Clement Koebernick, **Peng Chee** and Don Jones
Cotton leaf roll drawf virus (CLRDV), which cause the cotton blue disease (CBD), is regarded as the second most damaging virus disease to cotton production worldwide, capable of reducing yield by up to 80–90% on susceptible varieties in Argentina and Brazil where this disease is endemic in cotton. The recent discovery of CLRDV in Alabama, Georgia, Florida and South Carolina is causing great concern because this virus has the potential to severely damage the 2.5 million acres of cotton typically planted each year across the Southeastern US with an estimated farm gate value of $1.6 billion dollars. The isolates of CLRDV collected in Alabama and Georgia generally are closely related but not identical to the atypical CLRDV isolates reported from South America. Collaborative efforts across disciplines and across states are imperative to reducing the grower's risks. In this presentation, we will show the symptomology of diseased cotton plants observed in 2018–19 and provide an overview of the current research efforts on breeding, entomology and virus projects that ultimately will lead to an intrinsic solution to manage this new disease.

World leading yield progress: how the breeders did it
Warren C. Conaty and Greg A. Constable
Globally the Australian cotton industry enjoys some of the highest lint yields. Underpinning these impressive yields is the development of superior varieties, matched with grower management. The aim of this research is twofold: 1) to use direct cultivar comparison to assess the rate of genetic gain in the CSIRO cotton breeding program, and 2) to understand how factors within a conceptual yield development framework relate to yield progress. Using comprehensive field experiments, yield progress of 16.1 kg lint ha^{-1} y^{-1} was observed across ten conventional cultivars released between 1968 and 2012. This study identified that selection pressure on yield, fibre quality and disease resistance has also resulted in improvements in total dry matter (TDM), harvest index (HI), lint percentage and carbon assimilation. While gains have been made in these four parameters, improvements in lint yield have largely been driven by altering HI through increasing lint percentage. It is unlikely that further increase in lint percentage is possible due to the associations with small seed size and low seedling vigour. Future gains in lint yield will require the concurrent maintenance of harvest index while producing larger plants with more fruiting branches that capture more incident radiation with increased efficiency. This may require a longer fruiting period. As the collection of phenotype data such as biomass, boll number, boll size and radiation use efficiency at the scale required in a commercial breeding program is largely aspirational, we conclude in the short-term that improvements may be achieved through continuing direct selection for yield. Future efforts should be placed in increasing early season growth rates, and in the longer-term enhancing carbon assimilation rates. Importantly, due to associations between traits and the effects of trade-offs between functional components, factors must be considered in a whole crop framework and not in isolation.

Benchmarking water productivity in the cotton industry - The process and 2017/2018 results
Ben Crawley, Daowei Sun, Peter Regan, Jasim Uddin, Robert Hoogers, Iain Hume, David Perovic
Water is a vital input for cotton production, and one that is ever scarcer given the on-going drought conditions experienced in Australia. Given the challenges around water, Australian cotton growers have continually looked for ways to save water and to become more efficient and more productive with water, through improving conveyance, storage and irrigation systems, and improving agronomic practices. The Benchmarking water use efficiency in the Australian cotton industry project (DAN1505) led by NSW DPI has aimed to quantitatively measure water productivity across the Australian cotton industry and to monitor improvements over time. Here we provide (1) an update of the latest water productivity numbers, (2) give an overview of the methods we utilize to ensure the accuracy and robustness of these data, and finally (3) outline how we are streamlining data collection to increase the frequency of monitoring and turn-around and impact of results in the future.

Magnet® and related formulations as repellents for honey bees
Alice Del Socorro and Peter Gregg
Magnet® is an attract-and-kill technology developed in successive Cotton CRCs for management of adult *Helicoverpa* spp. in cotton. Following reductions in the market for the product due to adoption of transgenic cotton, we investigated its potential for use against diamondback moth in canola. Since canola is a favoured resource for beekeepers, it was necessary to examine its impact on bees. Rather than attracting bees, we found it to be highly repellent. We have since investigated the reasons for this effect. Canola oil, which is used to dissolve the plant volatile chemicals which attract *Helicoverpa* spp., is a powerful feeding deterrent for bees. When combined in formulations with a signal such as one of the plant volatile components of Magnet® it invokes a strong aversive learning response in bees, which might be exploited to deter bees from foraging in insecticide-treated crops. Other volatiles can be used for the same effect, including bee alarm pheromones. We will discuss what needs to be done to make this technology useful for protecting bees from insecticides in the field.

Photogrammetric Yield Estimation in Cotton with UAS

Will Dodge, Andrew Young, Paxton Payton, James Mahan

Photogrammetry, in its simplest form, is the practice measuring objects in photographs. The American Society for Photogrammetry and Remote Sensing, defines photogrammetry as "the art, science and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring, and interpreting photographic images and patterns of electromagnetic radiant imagery and other phenomena". Modern consumer grade UAS hardware and contemporary open source software packages make UAS based photogrammetry cheap and widely accessible. Push button systems allow users to collect image data with little effort. Currently the greatest challenge for anyone interested in operating a UAS is the licensing process itself, the actual operation of such devices is trivial. This research examines the potential for photogrammetric yield estimates in cotton as well as a generalized yield estimation model from image data gathered with an UAS. The yield estimation technique described is non-destructive and can provide yield information at a per-plant level of spatial granularity. The methodology, model development, and testing will be discussed.

Mapping the depth to a soil sodicity constraint, a useful tool for understanding cotton yield variability

Patrick Filippi, Thomas Bishop and Edward Jones

The soils of the cotton-growing valleys have characteristics that make them desirable for cropping, but soil constraints are still an issue. The most common constraint is high subsoil sodicity, which decreases the amount of water and nutrients accessible by crops, reducing yield. The depth at which a soil constraint is reached is important information for growers, but is difficult to measure or predict spatially. Typical digital soil mapping (DSM) studies create maps of soil properties at several depth increments of the profile, but this is too much information to easily make a management decision. A single map of the depth at which that constraint is reached would be invaluable. This would assist in identifying areas where rooting depth is inhibited, and help growers implement management to either rectify the issue or alter inputs according to the constrained potential. This study mapped the depth to a soil sodicity constraint across the whole Namoi Catchment to a 1 cm vertical resolution to 100 cm depth, and a 30 m horizontal resolution. Soil data consisted of 5624 samples from 1801 sites, and was obtained from a large public database, regional surveys, and farmers. The covariates for modelling included satellite imagery, terrain attributes, gamma radiometrics, and land use. Equal-area quadratic smoothing splines were used to resample vertical soil profile data, and a random forest (RF) model was used to produce the depth-to-soil sodicity constraint map. Different sodicity constraint thresholds of 6%, 10% and 15% were explored. The RF model was accurate, with a Lin's Concordance Correlation Coefficient (LCCC) of 0.58 when testing with 10-fold (leave-whole-site out) validation. The produced constraint map was analysed against cotton yield monitor data, with results showing that yield increased when a soil sodicity constraint was deeper in the profile. The impact of the reduced rooting depth on available water capacity (AWC), yield, and profit were also explored.

Using multi-layered, multi-farm datasets to forecast yield, identify yield gaps, and understand causes of variability in cotton

Patrick Filippi and Thomas Bishop

Cotton growers collect large amounts of spatial data (e.g. yield, EM surveys, management data), and there is an increasing amount of public spatio-temporal datasets available (e.g. satellite imagery, climate). All of these datasets represent the factors that drive yield, and are a promising opportunity to improve the management of cotton systems. Predictive models of cotton yield can be built when all these datasets are combined over many years and across many fields and farms. This study uses data from a 13,000-ha cotton farm in the Gwydir. Yield monitor data was available from 2002 to 2018, as well as proximally sensed data. This was combined with satellite imagery (EVI), climate data (rainfall, degree days), and terrain attributes. A random forest model was used to forecast final cotton yield from mid-season (January). Predictions were made at a range of resolutions, from 30 m, to fields. These were independently validated by leaving out whole fields/years. The model accuracy improved as the spatial resolution increased from a Lin's Concordance Correlation Coefficient (LCCC) of 0.51 and Root Mean Square Error (RMSE) of 1.60 at 30 m resolution, to a LCCC of 0.60 and RMSE of 1.38 at the field resolution. Forecasts of cotton yield are a valuable tool for matching inputs with expected yield, as well as managing risk. These models are also useful for identifying yield gaps and understanding the causes of yield variability. The random forest modelling allows for not just the expected yield to be modelled, but also the upper quantile (e.g. 95th percentile). This could be viewed as the yield potential, because given our dataset, this is the most the yield could be. Comparing yield potential with observed yield allows for yield gaps to be identified. This helps identify areas not reaching yield potential, and the consistency of not reaching this over a number of seasons points to the nature of the constraint, whether it is temporary, or permanent.

Tackling Verticillium Wilt from a Management Perspective

Bob Ford and Elsie Hudson

Verticillium Wilt has been increasing in its severity across many cotton growing regions in Australia. There is two ways to tackle the disease, from a Research and Farm Management perspective. The CSD extension team are concentrating their efforts on the latter in evaluating farm practices that may help with reducing the impacts of the disease on yield and the build-up of the disease propagules in the soil.

Results after two years of study would suggest there are correlations with previous USA studies on plant population effects on the disease. With higher plant population having less disease incidence. Conversely, while high Nitrogen in the trials produced high yield they also produced higher incidence of the disease.

Further work is looking at the propagule levels in the soil and where trial treatments have been placed in fields; to get a better and more precise understanding of the impact of the disease on management treatments in these trials.

Future-proofing cotton production by building resilient photosynthetic pathways
Demi Gamble, Michael Bange, Warren Conaty, David Tissue, Spencer Whitney and Robert Sharwood
In order to sustain and improve cotton production during increasingly hot future climates, 'future-proofing' cotton cultivars to tolerate extreme heat is required. One such approach that hasn't been exploited in cotton is the enhancement of photosynthetic performance and thermal resilience through modification of the key photosynthetic enzyme, Rubisco. Improved thermal optima and photosynthetic properties have been demonstrated in other crops such as wheat, rice and sorghum to be potential solutions to overcome the negative climatic impacts on crop productivity. Our research aims to elucidate diversity in photosynthetic performance and resilience against heat stress between diverse species of *Gossypium*, and cultivars of *Gossypium hirsutum*. An analysis of photosynthetic gas-exchange measurements and a range of biochemical assays to determine Rubisco catalytic properties forms the basis of this research. This presentation will elaborate on glasshouse experiments designed to derive the thermal optima of various *Gossypium* species and interrogate species-specific responses to heatwaves. We have uncovered significant diversity in multiple photosynthetic parameters at the leaf level and biochemical level. This variation appears to be related to genotype and climate of origin of the species. Determining the temperature dependency of photosynthesis for these diverse species will aid in understanding the impact of future climate change on cotton productivity, and what opportunities exist to modify photosynthetic performance to future-proof cotton cultivars.

Exploring nanofibrous coating on cotton fabric for versatile protection and dynamic comfort
Olga Gavrilenko
Cotton clothing is highly demanded due to the excellent comfort and serviceability of cotton fabrics. However, cotton fabrics provide only limited protection against liquids, including water, oil and chemicals. Using the electrospinning method, this PhD project aims to produce a versatile protective polyurethane nanofibrous/nanoparticles coating on cotton fabrics that would not compromise their comfort properties such as breathability, moisture management and durability. This presentation gives an overview of the progress and a summary of the findings so far and suggests future directions. Firstly, the individual and cumulative effects of electrospinning parameters were examined to produce nanofibrous/nanoparticles structures with specific morphology and to suggest a potential functionalisation mechanism. Secondly, the functionalisation technique was developed to eliminate water waste associated with the use of conventional coating methods by replacing them with electrospinning, which also allowed to apply the chemicals to the outer side of the fabric and to preserve the comfort qualities of its inner side. Thirdly, the formation of nanofibrous/nanoparticles structures over cotton fabrics with different weave/weight was examined together with the effects of the solvents and chemical concentrations. Finally, the protective performance, its durability to abrasion and laundering, and the comfort properties of the produced protective nanofibrous/nanoparticles coatings/cotton fabrics composite materials were examined, highlighting the advantages of the method over the conventional coatings. Future directions of the research are discussed.

Glycine as a bio-friendly mercerizing agent for cotton?

Rechana Remadevi, **Stuart Gordon**, Rangam Rajkhowa and Xungai Wang

Mercerisation is an old chemical process that is used to improve the mechanical and optical properties of cotton yarn or fabric. In mercerisation, cotton yarn or fabric is treated with a highly concentrated sodium hydroxide solution (up to 25 w/v %), which leads to swelling of the fibre and a change in the cellulose crystalline structure (from cellulose I to cellulose II). While mercerisation has been used for a long period, the process is not routinely used because it requires specific process machinery and the cost of the sodium hydroxide, and its disposal/neutralization. Moreover, strong alkali conditions are not suitable for cotton-polyester blends; where the polyester is hydrolysed by highly concentrated caustic treatment, (the ester linkages are broken. Ethane-1,2-diol is formed together with the salt of the carboxylic acid). In our project, we have developed a non-corrosive, amino acid (glycine) based method for treating cotton to improve the properties of cotton. In view of this, the present work uses a greener technology to mercerise cotton. The treatment involves applying glycine in an aqueous solution of glycine to cotton yarn wound in a dye package. Varying the pH provides an ability to change the glycine zwitterion and the amount of take-up by the cotton substrate. Dyeing studies showed that glycine treatment was beneficial for improved dye uptake. This increased dye uptake could be due to the ionic charge effect brought to the cotton cellulose by the glycine interaction. Furthermore, glycine treatment added some additional attributes to the cotton materials. Glycine treatments improved the handle properties of the cotton. Both objective and subjective analysing techniques were used to study the handle properties. From the handle property measurements, it was found that handle properties of the fabric have improved after glycine treatment. These results reveal a potential greener pathway for mercerisation of cotton with improved properties.

KEYNOTE: A comparative analysis of cotton and hemp production in Australia

Stuart Gordon and Rose Broderick

Proponents of the industrial hemp plant and those who market its fibre and other products often promote the perception that cotton produced in Australia and elsewhere is not an environmentally responsibly produced crop. The reasons used to support their contentions are that cotton production greatly overuses and misuses pesticides/crop protection products that have an adverse effect on the environment and agricultural workers, and that cotton overuses water and fertilizer to the same effects (sic). Factual documentation for many of the statements made is lacking and indeed some information used to support marketing programs for industrial hemp products is undocumented, misleading and incorrect.

The aim of this paper is to provide a comparative analysis of each crop's geographic range in Australia and the production volumes, unit production costs and realized farm incomes from the two crops as they are currently or could be produced. It is hoped the analysis will provide advocates representing either industry with a mutual understanding of the importance and potential of both crops. The authors note the two crops could easily co-exist in certain regions in Australia as productive crops in seasonal rotations on the same farm.

Honey bees and cotton

Peter Gregg

Albert Einstein once said that if bees disappeared from the earth, humans would follow within four years. While it does not appear likely that this theory will be put to the test in the near future, bees face many challenges in modern agroecosystems. One of them is poisoning by pesticides. Cotton areas are high-risk environments for beekeepers, both professional and amateur. Despite initiatives such as BeeConnected and Cottonmap which aim to improve communication between beekeepers and farmers, bee kills still occur. The reduction of insecticide use associated with Bollgard cotton may have encouraged beekeepers to let down their guard around cotton, but modern insecticides such as fipronil and the neonicotinoids pose special risks for bees. The spread of cotton into new areas, especially in southern Australia, has brought closer contact between bees and cotton. There is a need to improve Best Management Practices in relation to bees, and a need for techniques to discourage bees from foraging in insecticide treated crops.

Colletotrichum truncatum, a new causal agent associated with cotton boll rot in Australia

Aphrika Gregson and Duy Le

Cotton boll rot is caused by many different fungal and bacterial agents, and is amongst a large group of pathologies affecting the profitability of Australian cotton production. During state-wide disease surveys in the 2017/2018 season, rotten bolls were sampled for the confirmation of causal pathogens. On potato dextrose agar amended with 100 ppm of streptomycin (sPDA), putative cultures of *Alternaria* spp. were predominantly recovered. Two putative *Colletotrichum* sp. isolates were also recovered. Single-spored cultures of the two putative *Colletotrichum* sp. isolates appeared grey to brown and had a mean growth rate on sPDA at 25 ± 1°C in the dark of 9 mm/day. Conidia were aseptate, hyaline, thin walled, falcate and similar to those of *Colletotrichum truncatum*. The two sequences of the internal transcribed spacer (ITS) were 100% identical to the sequence (GenBank no. GU227862) of the type isolate of *C. truncatum*, thus confirming the identification. The pathogenicity of *C. truncatum* was assessed on cotton bolls. Unblemished, unopened bolls of uniform size from plants raised in the glasshouse were artificially inoculated with conidial suspension (104 conidia/ml) onto wounds. Sterile distilled water was used to mock inoculate controls. Bolls were incubated at 25 ± 1°C in the dark in high humidity for 10 days. By 7 days dark brown lesions were present on inoculated bolls, increasing to a diameter of 2–30 mm (mean = 10 mm, n = 14) by day 10 post-inoculation. Re-isolation of the pathogen was carried out as above and *C. truncatum* was successfully recovered, confirming Koch’s postulates. Anthracnose caused by *C. truncatum* is a cosmopolitan disease severely affecting a range of Solanaceae and Fabaceae hosts. In Australia, *C. truncatum* was detected on soybean, peanut, and noogoora burr hosts. To the authors’ knowledge, this is the first report of this fungus affecting cotton bolls in Australia.

Spatial and temporal visualisation of constraints of cotton root development in irrigated cotton in eastern Australia

Brendan Griffiths, Oliver Knox, Jamie Barwick, Tom Dowling.

During the years 2015 to 2018 an investigation was conducted to investigate the spatio-temporal distribution and extent to which cotton root development and general soil structural decline in the Eastern Australian irrigated cotton industry is occurring. A network of up to around 800 capacitance soil moisture monitoring probes was utilised, spread over a geographic area of 1000 km in length and 500 km in width. The dataset was interrogated with the view to locating probe sites with minimal or no root development below a depth of 60cm in the soil profile. Our investigations concluded that between 20 and 30% of all sites surveyed, in each of the three years, showed no root activity below the threshold of 60 cm. Since this initial survey the research team has been investigating spatial variability across the fields where probes were located, to better understand the distribution and extent to which these constraints are occurring at field level. Methods utilised in these field level investigations include establishing statistical relationships between spatial datasets collected via electromagnetic conductance and point sourced soil chemical datasets, collected from within those fields.

Quantifying radiation constraints for high yielding cotton production in tropical environments

Paul Grundy, Stephen Yeates and Kerry Bell

Bollgard 3 has instigated renewed interest in cotton production across northern Australia. Irregular solar radiation due to monsoon cloudiness can be an abiotic constraint; a likely consequence is altered canopy responses and disruption to boll setting. The extent to which crop compensation mechanisms may ameliorate boll losses due to cloudiness and improve yield potential will determine lint production reliability in some seasons. A 5 year study of cotton sown repeatedly within a 35 day window during the monsoon to expose different crop growth stages to varying amounts of cloud-related shading created a matrix of crop responses under field conditions to explore these relationships.

This style of experimentation informed testable strategies for fertiliser, irrigation and pix management practices that better balanced the propensity for rank growth during cloudy weather with the need for compensatory growth when sunny conditions returned. Whilst this work has informed growers attempting cotton production in northern Australia, a challenge was defining statistical relationships between crop response and cloudiness across multiple sowing times and seasons under field conditions. Highly varied biomass partitioning and yield responses were considered to have arisen due to the impact of cloudy conditions on boll retention.

Differences in intra-canopy distribution of bolls resulting from fruit abscission and subsequent compensation could be linked with the incident radiation environment during flowering. Clustering of treatments into groups based on intra-canopy boll number and distribution similarity, enabled growth and partitioning responses in relation to cloudiness-induced boll loss and subsequent compensation to be better interpreted. In this talk we will share both the methodology used to link radiation to crop response and some key conclusions that the impact of variable radiation has on fruit retention, biomass partitioning and RUE under tropical conditions.

A novel approach to monitor soil moisture in an irrigated cotton system

Si Yang Han, Patrick Filippi, Niranjan S. Wimalathunge, Thomas F.A. Bishop

With water scarcity increasing due to a variable climate and increased demand across all industries, water use efficiency in cotton production must continue to improve. There are limitations with how moisture is currently measured and estimated on a field scale, with most growers relying on capacitance probes which only measure at a single point. Accurate field-scale measurements of soil moisture are required to improve irrigation schedules and reduce water loss due to evaporation throughout the farm, and field seepage beyond the root zone. This project looked at the suitability of cosmic ray probe technology in measuring soil moisture in irrigated cotton systems, using a flood-irrigated commercial field in Narrabri as a case study. The results showed a promising correlation of 0.60 (R^2) between the neutron count derived from the cosmic ray technology and field sampled soil moisture. Despite this, actual soil moisture content was difficult to predict using this technology. This is likely due to limitations in the modelling methodology, which did not factor in crop biomass. Cosmic ray probe technology has primarily been used in natural and dryland systems, where the moisture content in surrounding plants is relatively low, or does not change much throughout the season. Some further analysis that included plant height and crop coefficient (Kc) in the model improved the relationship with soil moisture content (R^2 of 0.70). Future work will focus on creating a further improved methodology to account for the moisture content in crop biomass, such as estimation through remote sensing/satellite imagery. This technology shows high potential, and could be a useful tool to improve irrigation management in irrigated and dryland cotton enterprises.

The relationships between cotton colour grade, yarn quality and fabric dyability

Simone Heimoana And Robert Long

Open cotton bolls in the field may be affected by weathering during rainfall and/or by the black spores of sooty mould fungi. Both can cause discolouration of lint, leading to downgrades during classing and financial losses to growers. The colour of base grade Australian cotton is classed as 31 but is often better (21). Field experiments exposing open bolls to cumulative rainfall of up to 200 mm resulted in colour grades of 41–61. The addition of artificial insect honeydew to open bolls and subsequent exposure to warm and moist conditions produced moderate to severe sooty mould contamination, which resulted in colour grades of 41–71. HVI measurements of lint established that quality parameters other than colour were not affected as bolls used in the experiments were already mature. Lint samples were spun into yarns which were subjected to various tests before being knitted into fabric and dyed with Cibacron Blue. Yarn parameters were then regressed against cumulative rainfall (i.e. increasing colour deterioration). Count, twist, unevenness, neps, elongation, break force, thin and thick areas, tenacity and break work were unaffected by weathering and increasing amounts of rainfall (all R^2 = 0.32). The quality of yarn spun from cotton discoloured by sooty moulds was also unaffected (R^2 1 is perceptible). In fabric knitted from weathered cotton, differences in the raw fabric colour became progressively larger as colour grade deteriorated (R^2 = 0.91). Dyeing diminished these differences, but the relationship remained strong (R^2 = 0.86). Delta E values for fabric knitted from cotton discoloured by sooty moulds behaved similarly but were lower, with pre- and post-dyeing relationships less distinct (R^2 = 0.71; 0.37, respectively). We showed that colour downgrades affect how fabric holds dye and indicated two apparently different mechanisms of colour degradation.

Plastic Contamination Detection and Removal in Seed Cotton: Lab and Field Results

Mathew Pelletier, **Greg Holt**, John Wanjura

Plastic contamination in cotton lint, sourced from the plastic module wrap used to package seed cotton harvested from the John Deere round module harvesters, has become a major issue that is negatively impacting the cotton industry, specifically countries where all seed cotton is mechanically harvested. The impact of plastic contamination has risen to such a high level that the USDA-AMS (United States Department of Agriculture - Agricultural Marketing Service) classing offices have instituted new discount classing codes specifically identifying cotton bales contaminated with plastic. In response, the USDA-ARS (United States Department of Agriculture - Agricultural Research Service), Cotton Production and Processing Research Unit (CPPRU) in Lubbock, Texas has developed a color camera detection and removal system, known as the VIPR (Visual Imaging Plastic Removal) system, that installs on the cotton gin feeder apron, prior to the gin stand. This presentation reports on the development, laboratory testing, results, and field experience of installing the unit on a commercial cotton gin stand feeder apron during the 2018-2019 ginning season in West Texas. Also, being reported is a camera system, using the same technology as the VIPR system, installed in the module feeder as a protective system designed to alert gin management of plastic contamination trapped on the feed rollers.

Insecticide resistance status of *Bemisia tabaci* MEAM1 (Hemiptera: Aleyrodidae) in Australian cotton production valleys

Jamie Hopkinson, Stephanie Pumpa, Sharon van Brunschot, Grace Fang, Michael Frese, Wee Tek Tay and Tom Walsh

The whitefly *Bemisia tabaci* Middle East-Asia Minor 1 (MEAM1), previously known as B biotype, is a major agricultural pest with a reputation for developing resistance to insecticides. DNA-based identification revealed that B. tabaci MEAM1 is now the dominant species within Australian cotton cropping. Whitefly populations collected from cotton production regions in Queensland and New South Wales were tested for resistance in dose response bioassays to pyriproxyfen, diafenthiuron and bifenthrin. To determine the presence of resistance alleles to organophosphates and pyrethroids, a reference population of susceptible whiteflies and three populations with either pyriproxyfen, bifenthrin or neonicotinoid resistance were tested. This study reports on the presence of pyriproxyfen resistance in *B. tabaci* MEAM1 at five localities in Queensland and New South Wales. The knockdown resistance mutation L925I was found in a pyrethroid resistant population and in some individuals from a pyriproxyfen resistant population. The organophosphate resistance mutation F331W was found in all individuals tested including the susceptible reference population, suggesting that it likely is widespread in Australia. The Australian cotton industry has developed an insecticide resistance management strategy *for B. tabaci*, which recommends restricting the usage of pyriproxyfen to a single application within a 30-day window. Our results argue against the use of organophosphate and carbamate insecticides, because the Australian *B. tabaci* MEAM1 population is resistant and, as both of these pesticide groups are highly disruptive to their natural enemies, it can result in pest outbreaks.

KEYNOTE: Using innovation to manage difficult to control weeds in the Australian cotton system
Rick Horbury
Glyphosate is a critical herbicide for the cotton industry, and for agriculture in general, so protecting the longevity of the product is important. Over the last 20 years, over-reliance on glyphosate has seen a marked decrease in residual chemistry use within cotton systems and has also been a key contributor to the development of glyphosate resistance. Globally, weed species continue to evolve and resistance to not just glyphosate but other key herbicide modes-of-action is a real threat to future production. Whilst the problem of glyphosate resistance, and herbicide resistance in general is significant, it is manageable. Bayer remains committed to helping farmers manage herbicide resistance through new products, tools and programs. Rick will provide an overview of Bayer's commitment to understanding the changing landscape of weed resistance development and the impact this has on Bayer's R&D pipeline. This will include learnings from key researchers across the agriculture industry, local trials and industry survey results on weeds of importance (i.e. fleabane, barnyard grass and annual ryegrass) and how Bayer can continue to support farmers in the Australian cotton industry to manage weed challenges into the future.

Mapping the spatial extent of soil constraints at the farm-scale
Edward Jones, **Pat Hulme**, Brendan Malone, Patrick Filippi and Alex McBratney
This research presents a case study of applying digital soil mapping techniques to delineate the spatial extent of soil constraints on part of a large cotton farm in Queensland. A proximal sensing survey was conducted to collect electromagnetic induction, gamma radiometric and elevation data over an area covering ~2,000 ha. A cut and fill map and a bare soil redness index from the Landsat 5 satellite were combined with the data from the proximal sensing survey to create a covariate database. This data was used to direct the sampling of 70 soil cores at four depths (0–30, 30–60, 60–100, 100–140 cm) which were analysed in the laboratory for pH(1:5 $CaCl_2$), exchangeable cations, EC and texture (sand, silt, clay). Relationships between the laboratory measured properties and the covariate dataset were investigated and used to create surfaces of each property at the four depths across the study area. Correlations between modelled soil properties and cotton lint yield for the 2016–17 growing season and satellite borne vegetation indices for five years in total were investigated. Modelled soil properties were found to have greater correlations with cotton yield and vegetation indices than proximal sensed data alone. A multivariate yield model was constructed on a per field basis and used to deconvolute potential negative effects on yield from individual soil properties. This approach identified discrete locations across the study area where depth to an exchangeable sodium percentage (ESP) of 10%, depth to an electrical conductivity (EC_e) of 10 dS m^{-1}, and areas of reverse grade in elevation were likely to be responsible for reduced cotton yield. Delineation of yield constraints in this way provided insight into management options to ameliorate these constraints.

A new way to measure cotton's water productivity using Data Envelope Analysis and survey data

Iain Hume, Peter Regan, David Perovic

Benchmarking has been used to demonstrate continuous improvement in the water productivity of Australian cotton growers. One key performance indicator, water used per bale of cotton produced, has been used as the standard measure of performance. We examine the use of Data Envelopment Analysis (DEA) as a more flexible way to assess water productivity. DEA is a best practice economic benchmarking tool which identifies the frontier of most productive fields and measures the technical efficiency of each field as its distance from that frontier. This quantification of efficiency will allow the comparison of individual fields with the best performers. DEA uses the data to describe the productivity frontier under the technology prevailing at that time. It, therefore, measures how well fields are performing under the seasonal conditions prevailing at the location of data collection. This is advantageous as the frontier will shift in time and in space, and DEA will assess the efficiency with which individual fields or growers performed under those conditions. Another advantage of DEA is that it allows the comparison of multiple inputs, not just water. We use data collected by a Cotton Gin to first benchmark water productivity and second, to apply DEA to quantify the technical efficiency of cotton water productivity.

Maximising opportunities to share research

Jamie Iker (on behalf of Crop Consultants Australia Incorporated)

Private sector advisors are a key mechanism for delivering research data and scientific findings to growers in a practical manner for implementation at a paddock level. With regional differences playing such a strong influence in crop management and IPM practices, crop consultants are able to apply research findings and new information in a manner relevant to their grower's situation. With many crop consultants having long term relationships with their clients, this provides a supportive and trusting environment which can enable the testing of new ideas and result in innovative practice change. There are opportunities for researchers to engage more strongly with Crop Consultants Australia (CCA) to ensure new research and scientific information directly reaches crop consultants.

CCA has over 200 members situated across Australia's key cotton producing valleys and regions with a relatively even spread of members across Queensland (45%) and New South Wales (52%) along with 3% based in other states such as South Australia, Western Australia and Victoria. Of the membership, 60% are practicing agronomists, 30% are representatives of corporate businesses with the remaining 10% consisting of extension officers, researchers and representatives of key industry organisations. In 2018, the 63 CCA members who were surveyed represented 494 cotton growers and covered 293,785 hectares which was 56% of the Australia cotton production area for the 2017-18 season. By engaging with CCA, researchers and scientists are able to disseminate their research efficiently and effectively to a significant proportion of the cotton industry.

Coordinated opportunities available to engage with CCA members include: (1) Annual Cropping Solutions Seminar; (2) New quarterly Research E-Newsletter, and (3) Annual Cotton Consultants Survey.

Biology and management of *Sesbania cannabina* under a changing climate

Nadeem Iqbal, Sudheesh Manalil, Bhagirath S. Chauhan and Steve W. Adkins

Elevated levels of atmospheric carbon dioxide concentration (CO_2) and frequent droughts are two anticipated climate change scenarios in which certain invasive weeds may have competitive advantages over crops and adversely impact productivity. The extent of such impacts will be more severe if such scenarios also reduce the efficacy of glyphosate. Hence, a study was conducted to explore the growth of *Sesbania cannabina* (Retz.) Pers. and its susceptibility to glyphosate under different climatic scenarios. The variables investigated were two CO_2 concentrations (400 and 700 ppm), two soil moisture levels [100% and 50% of field capacity (FC)] and three rates of glyphosate [0 (control), 517 (50% of the recommended rate) and 1034 g a.i. ha^{-1} (recommended rate)]. Different atmospheric CO_2 and soil moisture levels applied had a significant effect on the growth and biomass production of *S. cannabina*. The maximum plant height (38.4 cm), leaves $plant^{-1}$ (20.0), growth index (60.3), chlorophyll contents (SPAD value 36.6), fresh biomass (9.9 g) and dry biomass (2.9 g) were recorded in the 100% FC and elevated CO_2 environment and vice versa was recorded in 50% FC and ambient CO_2. Generally, moisture stress had a negative effect on growth and biomass production except for root length which was increased in 50% FC environment. Furthermore, plants grown in the 50% FC and elevated atmospheric CO_2 environment recorded higher growth and biomass production in comparison with plants grown under the 50% FC and ambient atmospheric CO_2 environment. The recommended rate of glyphosate gave 100% weed biomass reduction under all climatic conditions tested, however, glyphosate efficacy was reduced to 63% under elevated CO_2 and moisture stress environment when applied at 50% of the recommended rate. *Sesbania cannabina* when grown under elevated CO_2 concentration and moisture-stress conditions showed reduced susceptibility to the lower rate of glyphosate.

Can canopy temperature sensors help inform irrigation scheduling decisions with limited water?

Hizbullah Jamali, Christopher Nunn, Tracey May, Victoria Smith, Darin Hodgson, Michael Bange

With prevailing drought in most cotton growing valleys in Australia, an increasing number of growers are considering growing cotton with less water. Growing cotton with limited water requires consideration of many factors when making irrigation decisions, some of which may include: quantity of water available for irrigation, soil moisture status at planting, soil type, seasonal and weather forecasts, row configurations, planting time, and a grower’s overall approach to risk. We are seeking to inform irrigation decisions in limited water systems by utilizing canopy temperature sensors which offer a quantifiable means of assessing crop stress. More specifically, we used canopy temperature sensors to determine the impact of varying the timing of a single irrigation after first flower. A detailed field experiment with four irrigation treatments was conducted at the Australian Cotton Research Institute, Narrabri, NSW during the 2018–19 cotton season. In the first treatment, irrigation was scheduled using the same canopy temperature stress time threshold used in fully irrigated systems. The remaining three treatments were scheduled with an increased stress time threshold to stretch the period between irrigations. Results showed that treatments with more stress over the course of the season had less yield, although the individual treatments did not perform in line with expectations. It was thought that there would be a clear trend for treatments with later irrigations to have lower yields, however this was not the case. The earliest treatment was the lowest yielding treatment because of lack of water access. The research has highlighted the utility of the canopy temperature approach to clearly identify the efficiency of irrigation approaches by quantifying crop stress. This will ultimately assist in optimising limited water cropping systems.

Understanding the ecology of reniform nematodes in Australian cotton

Dinesh Kafle, Tim Shuey, Dean Brookes, Linda Scheikowski and Linda Smith

The reniform nematode (*Rotylenchulus reniformis*) is a major parasite of cotton, significantly limiting plant growth and yield. The studies conducted in the USA show that the yield loss due to the reniform nematode is up to 11% of all losses caused by various cotton diseases. Soil surveys conducted by QDAF have confirmed the presence of reniform nematode populations in cotton fields of Central Queensland (Emerald and Theodore), although very little is known about the reniform ecology under Australian conditions. We conducted three different glasshouse experiments to assess: 1) the vertical movement of nematodes in vertisol in presence and absence of a host plant, 2) host/non-host suitability of different field crops, and 3) the pressure of different nematode populations on three cotton varieties. The vertical movement trial showed that reniform nematodes move upwards in the soil profile, most likely towards the food source (growing roots) as they did not move in the absence of a host plant. No reniform infestation was found on the roots of corn, wheat, forage or grain sorghum in the host/non-host trial, which confirms these crops are non-hosts and thus suitable as rotation crops. The reniform population trial showed that reniform nematode in high population significantly reduced the yield of one of the three varieties of cotton tested; suggesting cotton varieties differ in their response to reniform nematodes. In addition to the glasshouse trials, we compared the genetic diversity of reniform nematode found in different crops in Australia and with those found in cotton-growing regions abroad. Molecular analysis showed that the reniform nematode found in different crops in Australia are not different from each other or from those related to cotton internationally. Our results combined with the other available scientific findings on reniform nematode ecology will be helpful to devise a management plan to address the reniform nematode problem in Australian cotton.

The PGPR consortia can promote seed germination and plant growth of cotton crop (*Gossypium hirsutum*) crop

Simranjit Kaur, Zhiguang Qiu, Catriona A Macdonald, Eleonora Egidi and Brajesh K. Singh

Plant growth-promoting rhizobacteria (PGPR) application in farming system is an emerging sustainable approach to enhance plant growth and productivity. To determine PGPR efficacy in cotton (*Gossypium hirsutum*) to enhance germination, plant-growth, productivity and soil nutrient availability in different cotton cultivars (CIM448, Siokra L23, DP16, CS50 and Sicot 71BRF), a bacterial consortium was prepared using four PGPR strains: *Brevebacterium* spp., *Plantibacterium* spp., *Enterobacter* spp. and *Arthrobacter* spp., all harbouring indole-3-acetic acid production, P-solubilization and ammonia production traits. The inoculation of consortia on cotton plants was performed by (a) seed treatment at the time of sowing (b) soil treatment at true-leaf stage. The result showed that the use of PGPR consortia at time of sowing can increase germination rate by 12% compared to the control group, along with induction of earlier germination. Plant height at true-leaf stage (four-week stage) was 7.6% higher than control with significant difference likewise soil ammonia and nitrate significantly increased up to 17.7% and 40.8% over control. From the preliminary findings we conclude that PGPR consortia, with their multifaceted growth-promoting mechanisms can accelerate seed germination and plant growth at early stage, and represent a promising option for improving cotton farming productivity. Further analyses related to PGPR consortia's effect on soil phosphorus and rhizosphere microbial community structure is in progress.

Noogoora burr and its role in the dispersal of Verticillium wilt

Karen A. Kirkby, Toni A. Chapman, John D. Webster, James Hereward, Heather Smith, Linda Falconer, Graham W. Charles and Stephen B. Johnson

Verticillium wilt is caused by the soil borne fungus *Verticillium dahliae* which has a very large host range of over 400 species including many crops and numerous weed species. In 1967, research concluded a relatively high incidence of Verticillium wilt in first year cotton crops growing on old farming land was attributed to a build-up of inoculum on the roots of broad-leafed weeds such as Noogoora burr. In 1968, the infection process of Noogoora burr was studied and found the incidence of infected burrs from individual infected plants ranged from 0–75% with average seed infection of 40%. A single burr and enclosed pericarps were estimated to contain up to two thousand microsclerotia.

An infected Noogoora burr plant can contribute to the dispersal of a *V.dahliae*. The burrs carry the Verticillium wilt pathogen, enabling wide dispersion of the pathogen by animals or through irrigation channels, rivers and streams, and flood waters. Noogoora burr is known to be a host of V. dahliae, however the host susceptibility of the other species within the burr complex remain unreported. Neither the pathotype nor VCG within the Noogoora burr complex were known. The aims of this research were to 1. Determine host specificity of the V.dahliae within each of the species of the complex and to 2. Assign pathotype and VCGs to burr isolates. Burrs from 77 populations of the Noogoora burr complex were molecularly assigned as defoliating or non-defoliating pathotypes and further assigned VCGs for the first time.

Determining inoculum thresholds for Verticillium wilt in Australian cotton

Karen Kirkby, Sharlene Roser, Peter Lonergan

Over the past two seasons, NSW DPI has been working to establish a correlation between pre-season inoculum levels and disease incidence and severity. In Australia, this is not a simple task as 1 propagule per gram of soil can produce disease in cotton. Severity is influenced more by the fungal isolate virulence than by its vegetative compatibility group or pathotype. There is however a relationship between pre-season inoculum levels and the minimum disease incidence. As the inoculum levels increases, so too does the minimum disease incidence.

Microsclerotia can persist in the soil for at least 14 years without a host. The wetting of soil can stimulate microsclerotia to germinate repeatedly. Germination of microsclerotia is the first step in microsclerotia returning to vegetative growth and initiating wilt diseases. The range of disease potential from each level of inoculum observed in the plot trials may be explained by the fact each microsclerotia (or propagule) can germinate up to 13 times. Also each germinating microsclerotia can produce between 20 and 48 germinating hyphae depending on their size and the number of times the microsclerotia germinate.

From 140 individual plots, the average incidence of disease from each inoculum level up to 36 propagules per gram of soil was determined and used to produce a threshold for the minimum disease. This coming season, further work will be done to validate thresholds in commercial fields. Thresholds may vary under wet seasons, with different VCGs and fields with different nutritional status.

Herbicide resistant weeds, are they winning the battle? What are the surveys telling us?
Eric Koetz
Weeds are a significant threat in all northern farming systems. Glyphosate-tolerant cotton has been rapidly adopted by the Australian cotton industry since its introduction 13 years ago and currently accounts for nearly all of the crops sown. This has led to a change in weed management practices with growers moving away from applying residual herbicides in anticipation of a weed problem, to dealing with weed issues in the emerging crop and relying primarily on using glyphosate for weed control. Targeted weed surveys were conducted (2015–18) to collect seeds from surviving weeds for herbicide resistance screening, particularly to glyphosate. Greater than 90% of fleabane samples are resistant to glyphosate, 20% of sowthistle samples, windmill grass resistance levels fluctuated from 45–90% across years, feathertop Rhodes grass resistance levels are increasing and barnyard grass samples are between 45–65% resistant to glyphosate. The high levels of resistance recorded and the dependence on glyphosate as the main chemical control option is placing increasing pressure on the long term sustainability of the Australian cotton farming system. Integrating pre-emergent and residual herbicide in conjunction with targeted tillage is required in the long term.

Overview of Cotton Incorporated's Entomology Research Program and Insect Management in US Cotton
Ryan Kurtz
Cotton Incorporated is a non-profit organizations whose mission is to increase the demand for and profitability of cotton through research and promotion. Each year, Cotton Incorporated funds more than 300 research projects with universities, the US Department of Agriculture and private co-operators. This presentation will provide an overview of the key areas of emphasis in Cotton Incorporated's entomology research program, as well as an update on the current status of insect management in US cotton with a focus on major pests, resistance issues, and management practices.

Nitrogen Uptake Preferences and Capabilities of Cotton (*Gossypium hirsutum* L.)

James Oliver Latimer, Mark Farrell, Robert E. Sharwood

This is the first comprehensive study of the nitrogen (N) uptake preferences and capabilities of cotton (*Gossypium hirsutum* L.). Our experiment shows that *G. hirsutum*:

1. Can take up whole low molecular weight (LMW) dissolved organic N molecules (L-alanine, urea) from the soil without the aid of established mycorrhizae;
2. Displays negligible uptake preference between the mineral N (nitrate and ammonium) and organic N (urea and L-alanine) soil nutrient pools, and
3. Displays no appreciable preference between nitrate and ammonium

Mineral N (ammonium and nitrate) is thought of as the ideal form of N for plant uptake. It is, however, highly dynamic in soils, and easily lost through leaching or volatilisation. These losses can create serious environmental, economic, and reputational problems for the Australian cotton industry, and should be mitigated wherever possible. Our research indicates that LMW organic N molecules are equally preferred by the cotton plant to mineral N. This suggests that further emphasis on organic soil amendments could reduce N losses to runoff, deep drainage and volatilisation, while not affecting yields. Cotton may also experience an energy advantage in its biochemical reaction pathways when absorbing alanine over nitrate or ammonium, making it a preferred N source.

Three different varieties of cotton were used in this experiment to gauge whether breeding programs have altered the N uptake preferences of *G. hirsutum*: Sicot 746B3F, a genetically modified (GM) current commercial cultivar accounting for more than half of the 2017–18 Australian summer plantings; Sicala V2, an obsolete non-GM commercial cultivar; and Tx III, a native Guatemalan landrace accession representing the native origins of the commercial *G. hirsutum* varieties. Plants were grown in fully nutrient controlled sand-filled rhizotubes to a two- to four-leaf stage. Novel methods used in this study could also prove useful for further trials.

KEYNOTE: Alternaria leaf spot of cotton: a re-emerging disease associated with a new pathogen

Duy Le and Aphrika Gregson

Alternaria leaf spot (ALS) caused by *Alternaria macrospora* is a ubiquitous disease of cotton worldwide and in Australia, yet the disease only causes minor concern. In Australia, ALS outbreaks were recorded on Pima cotton grown near Katherine, Northern Territory and in Bourke, northern New South Wales (NSW). Recent severe occurrences of ALS on Upland cotton grown in southern NSW were proposed to be associated with a different species of *Alternaria*. Of a total 133 and 326 putative *Alternaria* isolates recovered from seedlings and mature cotton, respectively, more than 85% of the total isolates were identified as *Alternaria alternata* based on its morphology and sequences of the internal transcribed spacer (ITS) and translation elongation factor 1 alpha (TEF1) regions. Seven *Alternaria*-like isolates recovered from ALS seedlings could represent a novel species to the literature. No *A. macrospora* was detected within the prevailing population. Under glasshouse conditions, representative isolates of *A. alternata* were capable of inducing ALS symptoms similar to those observed in field, thus confirming the pathogenicity of *A. alternaria* on cotton. Additionally, *A. alternaria* was found more virulent on detached cotton leaves at 20°C than did at 25°C. Of 10 fungicides tested for their in vitro control efficacy, *A. alternaria* was sensitive to all, but one. The fungicide efficacy was also assessed in glasshouse trials. The fungicides were sprayed on cotton seedlings ten days after inoculation with *A. alternaria* when ALS symptoms were well-developed. Only three of the tested fungicides were capable of reducing the disease progress by about 10% compared to the un-sprayed control. Spray damage was also observed on seedlings. Further assessments are warranted to optimise timing and rate of fungicide applications.

Can Sentinel-2 accurately estimate in-season cotton nitrogen status and lint yield?

Stephen Leo, Max De Antoni Migliorati, Peter Grace

Cotton petiole nitrate and leaf nitrogen (N) are key parameters monitored to guide in-season N management. However, the applicability of plant sampling is limited due to its costs, time requirements, and within-field spatio-temporal variability. Management zone (MZ) delineation combined with canopy reflectance offers potential to improve in-season N management through variable rate application. This study assessed petiole nitrate, leaf N and lint yield response to increasing N rates across MZs on a cotton farm during the 2018/19 season in SE QLD. The potential of Sentinel-2 to estimate cotton parameters was evaluated and compared against a proximal sensor (Crop Circle ACS-470). Two MZs were delineated (HIGH and LOW), and N treatments received 80 kg N ha^{-1} pre-planting plus a top-up dressing varying between 0 and 120 kg N ha^{-1}. Six vegetation indices (VIs) were calculated and extracted from all available dates. Minimal lint yield response was observed to increasing N rates due to limited seasonal water availability. However, a response was observed across MZs, with LOW displaying significantly higher lint yields in some N treatments compared to the same N treatments in HIGH. This response was not reflected in the VIs, with a substantially lower VI reflectance in LOW compared to HIGH. Petiole nitrate, leaf N and lint yield were accurately estimated as early as flowering but the optimal VI was MZ-dependent. The red-edge chlorophyll index (CIre) and the normalised difference red-edge index (NDRE) performed better in HIGH, and the normalised difference vegetation index (NDVI) and the optimised soil adjusted vegetation index (OSAVI) performed better in LOW. Sentinel-2 derived VIs provided different absolute reflectance values to the ACS-470, but displayed a very similar pattern, with CIre performing best. These results indicate a substantial potential for Sentinel-2 to be used as a cost-effective source of information to guide in-season N application and estimate yield.

Genomic Selection - A new breeding tool

Zitong Li and Philippe Moncuquet

Genomic selection (GS) is a promising new breeding tool that estimates performance of individuals based on their genome-wide marker (genotype) data by using a statistical model built from phenotypic and marker data previously collected from a training population. The training population needs to be relevant to the breeding objectives of the program and cover the founder varieties and/or lines contributing genetic alleles into breeder's populations. A GS model is initially built that best estimates genetic effects (positive, negative, or neutral) simultaneously for all markers spread across the genome as random effects contributing towards each of the phenotypes being measured. Once trained, the model can be used to calculate the genomic estimated breeding values (trait performance) of individuals that are related to the training population, merely based on their genotype information. Prediction accuracies are assessed when the phenotypes of these individuals become available. The model can be refined as more data is collected to increase its prediction accuracy. Thus, GS can potentially reduce the need for phenotyping during a selection cycle and so can greatly increase trait performance/genetic gain per year relative to conventional phenotype based selection. GS has been used extensively in cattle breeding, but not widely applied yet in crop plants.

We are currently investigating the use of GS to improve performance of agronomic traits in CSIRO's cotton breeding program. We used these data to investigate the potential for GS as a breeding tool in cotton to predict fibre quality traits and to define the pilot breeding studies that need to be developed to test and transition to genomics-assisted selection methods. The long-term goal of this research is to optimize GS approaches and use it in cotton breeding to fast track the release of improved cotton varieties.

Optimal investment decision for cotton farm micro-grid designs
Yunfeng Lin
This paper presents an investment optimization model for cotton farm microgrid designs, which explores available renewable energy source (RES) and storage options. The designed microgrid includes solar photovoltaic, wind turbine generator and battery storage. The investment cost of the RESs and battery storage systems are considered in the microgrid design so that the payback period can be minimized. Based on the input of farm data and historical weather data, an objective function involving the initial setup cost and maintenance/operation cost is optimized to reduce the energy consumption and reliance on grid electricity and diesel. A case study in Gunnedah NSW is performed to validate and verify the proposed approach. In this case study, the main load includes three irrigation water pumps with a maximum power of 187 kW. Genetic algorithm is applied to obtain the optimization result for the particular cotton farm. Different weighting coefficients in the optimization model are tested in the case study to investigate the impact of decision preference on the operational cost, investment cost and payback period. In a higher weight on the operational cost and the lower weights on the investment cost and payback period, the obtained operational cost is lower while the capital investment is higher, and the payback period longer. As for the case study result, when the weights are chosen as 40% for the operational cost, 30% for the capital cost, and 30% for the payback period cost, the optimized operational cost is AU$18,053/year, the capital investment is AU$371,000, and the payback period is 14.66 years. The corresponding designed microgrid consists of a 60 kW PV system, four wind turbines with a total capacity of 80 kW, and an 81 kWh battery storage system.

The next breakthrough in cotton productivity: seed yield components
Shiming Liu, Sally-Ann Walford, Jenny Koebernick, Heidi Clement, Louise Zemcevicius, Leah Rood-England, Warwick Stiller, Greg Constable, Danny Llewellyn
Cotton is a unique field crop able to deliver two important agricultural commodities at harvest; long spinnable natural fibres as well as seeds enriched with oil and protein. High lint yield is always the primary target in the industry and in applied research. In fact, individual fibres are protrusions of single epidermal cells on the seeds; and lint yield, as the collective mass of these individuals, represents only a fraction of harvestable seed cotton. This intrinsic biology suggests seeds are not just where fibres are anchored but more importantly regulate how lint yield is expressed. In this presentation, we will provide a contemporary view of cotton seed development to highlight the timely coordination of the initiation and formation of fibres on the developing seeds that are also laying down reserves for when the seeds germinate. For future breakthroughs in cotton productivity, we propose that the key is to enhance seed production through a fine-tuning of the above processes. To support this hypothesis, we will provide two research outcomes for illustration. The first is based on field performance of GM lines which over-express combinations of three transcription factor genes with the aim of increasing fibre initiation to potentially increase lint yield. We will demonstrate how the GM traits affected fibre yield and quality, while driven by different promoters. The second approach is based on two seasons of field evaluation of a Multi-parent Advanced Generation Intercross (MAGIC) population, in which we will show the variation and interrelation of different fibre and seed yield components. This includes the fraction of lint and fuzz, seed weight and oil content, and demonstrates how conventional selection for one component can lead to shifts in others. These results highlight the challenges imposed on plant breeding by the physiological and metabolic interconnections between some of these yield variables.

The impact of Feral Pigs (*Sus scrofa*) on cotton and their effective control
Tony Lockrey and Darren Marshall
The Australian Cotton industry has a strong history of scientific investigation resulting in a dynamic management strategy. More commonly thought of as a pest of grain crops and pasture, feral pigs (*Sus scrofa*) have not consistently been on the radar as a major pest of cotton. In recent seasons, with dryland cotton displacing summer grain crop hectares, feral pig damage has escalated as they eat cotton bolls to complete their dietary requirements to breed. There is a knowledge gap amongst growers, agronomists and researchers to accurately quantify this damage and even less is known about how to effectively manage. For the past two years there has been world leading research conducted by a PhD candidate, Darren Marshall, with local support from growers, LLS, Landcare and Gwydir Valley Irrigators Association to better understand home range, disease vectoring and control tactics for feral pigs. GPS collars were deployed for two years and cameras for 6 mths to motivate participation in control. Aerial shooting and coordinated baiting have been found to be the only two effective control measures currently, at a landscape scale, to reduce feral pig populations by greater than the required 80% for significant impact. Tony, an agronomist, cotton grower and aerial contract shooter, brings a hands on and unique perspective on the damage and control of feral pigs. This is a call to research bodies and supporters to recognise and start to prioritise this research in their thinking, to research effective monitoring and control methods or strategies that are not currently utilised.

PLENARY: How to have science lead practice and behaviour change in rural industry
Mike Logan
Cotton has been seen as a leader in R&D adoption. The biggest challenge we faced during the 1990's and early 2000's was an existential threat. We were on the brink of being legislated out of business. Yet, changing practices was resisted at all levels. How did we go about introducing and managing a science based solution against a strong tide of resistance? This presentation will explain: (1) The need for change of practice and behaviour in the cotton farming industry; (2) the depth of the resistance to change; (3) the steps we took to overcome the resistance; (4) where the science came in, and (5) how we took the industry with us. Then, we will look back and: (1) examine the learnings of each phase of introducing change; (2) describe the architecture of introducing science based solutions to change practice and behaviour in agriculture, and (3) create a simple model to follow in future.

Machine vision App for automated cotton insect counting: initial development and first results
Derek Long, Paul Grundy and Alison McCarthy
Silverleaf whitefly, cotton aphids and spider mites cause cotton yield loss through plant feeding and lint contamination from waste secretions. Agronomists determine control action to manage pest insects from weekly monitoring of changes in pest counts. This manual sampling is labour-intensive as hundreds of leaves are sampled at 20–30 leaves per management unit and examined by eye for the presence and density of each pest. Machine vision has potential to automate pest counting on each leaf using infield cameras and image analysis software. The machine vision algorithms can be transferred to an App to enable real-time photo capture and analysis for pest counting using mobile devices. This App would standardise pest counting between different observers, improve chemical control decisions, provide a convenient method for logging and viewing data for each field, and inform Area Wide Management from silverleaf whitefly nymph counts. Data collection and software development have been conducted to develop the image analysis algorithms for detecting silverleaf whitefly nymphs. A dataset of training images was captured from glasshouses cultures of whitefly and commercial cotton farms in southern Queensland with three smartphone models. Two image analysis algorithms were developed using segmentation and machine learning to extract numbers of silverleaf whitefly nymphs (third/fourth instar) on each leaf. The segmentation-based approach and machine learning approach detected silverleaf whitely nymphs with up to 67% and 79% accuracy, respectively. The image analysis algorithms will be refined through parameter optimisation and incorporated into an App that will be evaluated by agronomists in the 2019/20 season. The image analysis algorithms will be extended to cotton aphids and mites as all three insects can occur simultaneously.

Measuring the maturity of unopened cotton bolls with near infrared spectroscopy
Robert L. Long
The boll cutting technique allows cotton producers to gauge the maturity of cotton bolls. The aim of this work was to assess the feasibility of using near infrared portable technology as a non-destructive rapid replacement for the boll cutting technique. Near infrared spectra (702–1100 nm) were collected from bolls using a Felix F-750 Produce Quality Meter. Spectra were successfully calibrated with two levels of boll maturity using a partial least squares model. This work demonstrates a potential future where such technology integrated with autonomous systems could enable the automatic measurement of cotton boll maturity.

Cotton fibre moisture measurements

Robert L. Long

Cotton fibre has a natural ability to uptake and harbour moisture. This property is linked to the wearability and comfort offered by cotton clothing, and it is a property that the synthetic fibre industry desires to emulate in less expensive alternatives like polyester. The aim of this research was to assess the moisture holding capacity of 40 cotton genotypes using four different methods. Results showed that there were detectable differences between the cotton genotypes in their ability to uptake moisture. This indicates that this fibre quality attribute is likely to be a heritable manipulatable trait, that could be improved using either traditional breeding or molecular approaches.

Mycorrhizae as parasites? Evidence from a range of summer crops

Emma Longworth, Richard Flavel, Chris Guppy, Oliver Knox

Arbuscular mycorrhizal (AM) fungi are important soil biota that form symbioses with most terrestrial plants to enhance nutrient acquisition in exchange for photosynthate. The effects of AM symbiosis can include negative, neutral and positive growth responses, however, the mechanisms and conditions driving this variability remain uncertain. There are few quantitative studies that compare a range of summer crop plant species response to AM colonisation. The effect of a commercial mycorrhizal inoculant on AM colonisation, shoot dry mass and phosphorus (P) and zinc (Zn) plant tissue content of cotton, maize, mungbean, sorghum and soybean plants in an extreme low P Tenosol soil was investigated. Plants were grown either with AM inoculant or without, in an unsterilised soil that had an existing native AM community. Inoculation increased mycorrhizal colonisation by 18% across all species. However, inoculated plants produced 15% less shoot dry matter and recovered 14-15% less P and Zn than un-inoculated plants. All crop species, excluding soybean, had a P tissue concentration below the critical value, but only maize and sorghum showed visual symptoms of P deficiency. These results demonstrate that under these conditions this commercial mycorrhizal inoculant can act as a parasite due to the net negative effect on plant growth and nutrient acquisition. This ineffective symbiosis may be explained by either a higher carbon (C) cost to the plant caused by the increased AM colonisation or that the inoculant competed with the native AM species and was less efficient at delivering P, resulting in reduced plant growth or both.

Canopy temperature monitoring in cotton. Now that I have all these numbers what can they tell me?
James Mahan
Measurement of canopy temperature in crops is becoming more common. Canopy temperature is used in production and research settings as a means to detect/quantify stress and for irrigation management. Over the course of a growing season, near-continuous monitoring can produce ~10,000 measurements per device. In this presentation, I will discuss: 1. some tips on assessing data quality and field performance of devices 2. how canopy temperature can be used to assess optimal and less-than-optimal metabolic states of the crop 3. how canopy temperature is related to crop water use 4. some approaches to visualizing seasonal canopy temperature

Climbing the Digital Literacy Mountain made easy. It only takes more rope and a bigger ladder
Tracey May, Hiz Jamali, Natalie Lui
Data generated by automated sensors today creates millions of lines of data. Ancillary data required to carry out analyses, such as weather and agronomic measurements, are also essential inputs, and large-scale multi spectral imagery is a powerful tool which requires capability in the use of Machine Learning techniques. There is a high demand from scientists and clients for this kind of data, yet there is commonly a skills disconnect where most scientists are never taught basic skills for research computing. With this volume of data comes the challenge of checking, cleaning and processing this information. There is a lot of data to mine and manage, yet not enough people with the skills or confidence to do this.

KEYNOTE: In-season yield prediction using VARIwise

Alison McCarthy, Kieran O'Keeffe and Andrew McKay

In-season yield prediction supports improved agronomic management and planning for crop sales and insurance contracts. Yield is currently often estimated using rules of thumb and manual boll counts. Data analytics approaches have been developed using site- and season-specific multi-spectral satellite imagery-based correlations that require significant datasets for wider scale transferability. An alternative approach is to forecast yield using known soil-plant-atmosphere interactions in crop production models and calibrated using available field data. USQ has developed software â€˜VARIwiseâ€™ to provide yield prediction throughout the season combining these models with: (i) plant parameters extracted from UAV imagery using image analysis; (ii) online soil and weather data; and (iii) on-farm management information.
In the 2017/18 and 2018/19 seasons, VARIwise was evaluated at one cotton site in Goondiwindi and 16 sites in Griffith. Management zones in the field monitored using the UAV were identified from vegetation index surveys, yield maps or satellite images. Phantom 4 UAV imagery was collected monthly at each site between January and picking for calibrating the crop model. The sites had varying levels of fruit removal, hail damage and heat stress.
In the 2017/18 Griffith trial, the percentage yield prediction errors were 10.2% in January, 6.0% in February, 2.5% in March, and 0.5% at picking, and in the 2018/19 Griffith trial the errors were 18.8% in January, 4.9% in February, 9.5% in March, and 10.1% at picking. In the 2018/19 Goondiwindi trial, the yield prediction percentage errors were 8.7% in February, 5.9% in March, 7.1% in April and 2.6% in May. The prediction errors at Griffith were higher in the 2018/19 season than the 2017/18 season because the sites experienced heat stress that are not currently represented within the VARIwise crop model. The yield predictor will be evaluated in 2019/20 to improve performance under insect and hail damage.

Evergreen Skills for an Uncertain Future in the Cotton Industry

Nicole McDonald

The future of work is shaped by several broad trends including digital disruption. How technology will change and replace tasks and jobs and what skills are required to transition to a digital future is of concern to all industries. The cotton industry will need to compete with a number of industries to attract the STEM skilled talent required and identify skills needed to be developed to adapt to expected changes in the way we work. The current research project sought to better understand how recent entrants, or those who had a significant change of role in the industry, transitioned into their roles and the skills they needed to develop to master their jobs now and into the future. While developing technical skills around digital technologies was mentioned, the overwhelming response from participants (employees and employers) was the requirement for a range of adaptability skills and evergreen skills in order to thrive at work. Implications for workforce management and development are considered.

Behaviour Change Interventions for Improved Spray Application on Farms

L.J. McLeod and D.W. Hine

Improving spray application practices is key in reducing the incidence of spray drift within the agricultural sector. This involves changing current human behaviours and encouraging the adoption of new behaviours. Providing information through educational campaigns is an important first step for increasing awareness and shifting attitudes. But contemporary behaviour change literature shows that providing information by itself is seldom enough to change behaviour, particularly when dealing with such a complex issue. A successful behaviour change intervention needs to consider all the factors, not just awareness and knowledge, which promote or impede the required actions. Understanding the capabilities, opportunities and motivations of your target audience is a crucial step in developing more effective interventions.

This presentation details research that has used an integrative framework developed from the behaviour change literature to identify a range of key behaviours that underpin the spray drift problem, from the planning through to the implementation and post-spraying stages. It then moves on to discuss the findings of a grower survey that investigated the main drivers of, and barrier to, these key behaviours, and how this information can be used to identify the main leverage points for initiating and sustaining behaviour change within specific grower segments. Our research results emphasise the value of adopting approaches incorporating human behaviour and persuasive communication theory to enhance spray application practices on farms.

What is driving the sporadic cotton-lint yield response to phosphorus fertiliser?

Clarence Mercer, Gunasekhar Nachimuthu, Graeme Schwenke, Jon Baird, Annabelle McPherson, Andy Hundt, Michael Bell, Chris Guppy and Richard Flavel

Previous phosphorus (P) response studies with banded P application in Australian cotton fields suggested a critical soil Colwell P of 6 mg/kg. However, more recent Queensland studies found that cotton was more responsive to P fertiliser that was dispersed through the topsoil than P that was banded. The resulting uncertainty, combined with a lack of understanding of the effect of wetting and drying cycles on P availability, led to field investigations conducted at the Australian Cotton Research Institute in 2017–18 and 2018–19 to study the interaction of irrigation cycles (IC), nitrogen (N) and P applications on cotton root morphology and lint yield.

In 2017–18, lint yields increased by 14% in response to N and 11% in response to P in a field with Colwell P concentrations of 42 and 31 mg P/kg at 0-15 and 15-30 cm depths respectively. There were also interactive effects of N, P and IC treatments. Seed P export ranged from 30 to 35 kg P/ha in crops yielding 12-17.5 bales/ha, despite total P uptake and seed P concentrations not being influenced by any of the treatments. The variation in P export occurred in response to N and P application but not to IC treatment. A parallel investigation in the same season found a 10.6% yield response to P fertiliser in a field with Colwell P levels of 39 and 14 mg/kg at 0-10 and 10-30 cm depth and a history of cotton-wheat-vetch rotation.

In contrast, there were no yield responses to P application in 2018–19 in a field rotated from sorghum having Colwell P concentrations of 49 and 32 mg P/kg at 0-15 cm and 15-30 cm depth. Mean root length density (RLD) 73 days after planting was greater in plots with applied P fertiliser than in those without added P (0.71 vs 0.63 cm/cm^3). Interactions between N and I, as well as P and I were also observed, with RLD higher in less-frequently irrigated plots with applied N and P (0.69 vs 0.59 cm/cm^3 and 0.71 vs 0.56 cm/cm^3 respectively). P effects were absent by the boll opening stage. However, an increase in mean RLD was seen in plots with applied N (1.04 vs 0.92 cm/cm^3), with an observed interaction between N and I in the more frequently irrigated plots showing an increase in RLD of 0.22 cm/cm^3.

An on-farm trial near Boggabri with a Colwell P of 51 and 25 mg P/kg at 0-15 cm and 15-30 cm depth receiving overhead irrigation also showed no yield response to P fertiliser in the 2018–19 season. These sporadic P responses in fields with Colwell P concentrations well above the previously suggested critical value suggests that factors other than soil P status are determining fertiliser P responses.

Genomic Selection - A new breeding tool

Philippe Moncuquet

Genomic selection (GS) is a promising new breeding tool that estimates performance of individuals based on their genome-wide marker (genotype) data by using a statistical model built from phenotypic and marker data previously collected from a training population. The training population needs to be relevant to the breeding objectives of the program and cover the founder varieties and/or lines contributing genetic alleles into breeder's populations. A GS model is initially built that best estimates genetic effects (positive, negative, or neutral) simultaneously for all markers spread across the genome as random effects contributing towards each of the phenotypes being measured. Once trained, the model can be used to calculate the genomic estimated breeding values (trait performance) of individuals that are related to the training population, merely based on their genotype information. Prediction accuracies are assessed when the phenotypes of these individuals become available. The model can be refined as more data is collected to increase its prediction accuracy. Thus, GS can potentially reduce the need for phenotyping during a selection cycle and so can greatly increase trait performance/genetic gain per year relative to conventional phenotype based selection. GS has been used extensively in cattle breeding, but not widely applied yet in crop plants.

We are currently investigating the use of GS to improve performance of agronomic traits in CSIRO's cotton breeding program. We used these data to investigate the potential for GS as a breeding tool in cotton to predict fibre quality traits and to define the pilot breeding studies that need to be developed to test and transition to genomics-assisted selection methods. The long-term goal of this research is to optimize GS approaches and use it in cotton breeding to fast track the release of improved cotton varieties.

From rice to cotton: Assessing physical conditions of irrigated soil in the NSW Riverina

Jonothon Moore

The Murrumbidgee Valley of southern NSW exhibits a variety of soil types, many of which are used for irrigated summer cropping, traditionally rice. Rice production relies upon lengthy periods of flood irrigation each season, along with intensive tillage practices including impact compaction, resulting in compacted structures. The natural phenomenon of soil coalescence is also common in the region. Over the past decade the Australian cotton industry has expanded into new growing regions within southern NSW. This has led to soils traditionally used to grow rice being brought into cotton production. A potential consequence of this is that while a hardened layer, caused by coalescence or compaction, may negatively impact cotton production through root growth inhibition.

This study examined the soil condition following changes from rice to cotton production on two properties with different soil types. Three treatments; soil still used to produce rice, a soil recently converted from rice to cotton (<3 years) and a soil previously converted to cotton (> 3 years), and a control (virgin) soil were assessed on two soil types, a Red Chromosol (Coleambally Irrigation Area) and a Grey Vertosol (Murrumbidgee Irrigation Area). There were three sites per treatment. At the three depths of 0 cm, 20 cm and 30 cm, soil strength was measured and bulk density cores (three per depth) were collected. Sorptivity, steady state infiltration and hydraulic conductivity were measured at the surface. Laboratory chemical analyses, ASWAT scoring and particle size analysis were conducted on soil from the surface (0-10 cm) and at depth (30-50 cm). This will assist in identifying if the two soils, currently being brought into cotton production, are able to respond to previously applied structural stresses. The assessment of soil chemical and physical characteristics can potentially improve land management decisions in new cotton production areas.

PLENARY: On-farm and off-farm sustainability: Everything you don’t want to hear from a fibre refugee
Gunasekhar Nachimuthu
Growing up in rural India, my career and life revolved within a comfort zone of 100 km from my home until I finished my Master’s degree in Agriculture. I made a decision to extend my comfort zone to acquire overseas qualifications and experience. I threw myself into that challenge and was navigating through my research career in Australia. The cotton science community surprised me with a reward of recognising my early career work at the 2017 Australian cotton science conference. A plenary talk by Early Career Award recipient in subsequent conference was suggested by AACS which threw a new challenge on me as plenary talks are often offered by highly experienced individuals. As an Early Career Award recipient, my talk will be briefly on my career journey and research. Anyway, what is the meaning of fibre refugee? Is it related to cotton or wool or synthetic fibres or something else? All will be revealed in my plenary.

New generalised probabilistic forecasting model for estimating canopy temperature applied to cotton crops
Quanxi Shao, Rose Brodrick, Scott Chapman, Hizbullah Jamali, Huidong Jin, James Mahan, **Christopher Nunn**, Humaira Sultana, Bangyou Zheng and Michael Bange
Continuous measurement of canopy temperature is an important indicator of plant water status of crops and has significant utility for irrigation scheduling. Importantly irrigators need to know in advance when their crops need to be irrigated and therefore the ability to predict canopy temperature accurately into the near future using the weather forecasts is necessary. Here a new approach is presented here to more accurately predict canopy temperature from forecasted weather variables. Unlike existing models which only consider only the linear correlation of canopy temperature to weather variables, the proposed model (developed through CSIRO’s Future Science Platform Digiscape) allows the model parameters to vary according to periodic functions which are designed to capture the variation over the time of the day. The continuity of parameter changes is guaranteed by varying the model parameters periodically and smoothly. The model is also designed in a manner that it is not specific to any specific crop. In this presentation we present two case studies using cotton experiments from Australia and the United States where this new approach is applied to assess its performance to predict canopy temperature compared to existing published models. Results show that the proposed model is superior to the existing published models in its ability to predict canopy temperature into the future and has utility in assessing when crop stress will occur, to assist with irrigation scheduling. Further evaluations suggested that the air temperature is a dominant weather variable for forecasting canopy temperature, but the inclusion of the other weather variables further improves the forecast.

A study on the effect of cold plasma treatment on cotton seed germination under water stress
Christopher Nunn, Gerard J.J.B. de Groot, Mark Wilson, Tony Murphy and Michael P. Bange
Germination and seedling stages are critical for healthy plant growth. The presence of pathogens, water stress and other abiotic stresses (temperature and salt) at these stages can affect the successful establishment of crop. Plasma treatment of seeds is emerging as a new technology platform to address these issues. In three years of studies supported by the FastStart® initiative, the effects of a range of plasma treatments on germination of cotton seeds were investigated. Plasma treatment was shown to improve germination in 4-day warm germination test and in a metabolic chilling test. Imbibition and seed coating tests showed a change in the surface of the seed, with potential improvements in performance of seed germination in water limited conditions. The research highlighted the need for controlled tests to assess the moisture stress tolerance variability in seed germination. A polyethylene glycol (PEG) solution was used to simulate moisture deficit during seed germination. These results showed that cold plasma treated seeds imbibed water at a faster rate and germinated earlier, in both normal and water stressed conditions, and increased water stress conditions in which germination was possible. The PEG treatments used in these trials showed that controlled assessment of moisture stress under laboratory conditions is possible and that this method may be of benefit more generally for seed assessment.

Compacted and suppressed: physical constraints of soil microbial response to carbon supply in the subsoil
Yui Osanai, Oliver Knox, Brian Wilson
Recent studies highlight the importance of dissolved organic carbon (DOC) in soil carbon (C) dynamics through microbial processes. Both the quantity and spatial accessibility of DOC influence the relative importance of microbial processes compared with physical processes. However, the extent to which microbial activity responds to DOC and differences in physical condition through the soil profile remain largely unknown. Here, we conducted a laboratory incubation to quantify microbial respiration responses to DOC in the topsoil (0–30 cm) and the subsoil (30–100 cm) along a simulated soil compaction gradient (disturbed, no adjustment, slightly compacted and compacted), using the soils collected from cotton-based cropping systems under different tillage and rotational managements. Preliminary analysis showed that basal respiration decreased in response to compaction, but increased following disturbance in both topsoil and subsoil. DOC addition increased microbial respiration. However, the response differed between the physical treatments and soil profiles. Both disturbance and compaction resulted in reduced respiration, with a greater reduction observed in the topsoil than the subsoil. When adjusted for field bulk density, the estimated respiration responses to DOC showed much larger responses in the topsoil than the subsoil and in maximum tillage than minimum tillage systems. These results suggest that under field conditions, subsoil respiration will be lower than that of the topsoil due to both physical and substrate constraints. The contrasting effect of disturbance on basal and DOC-induced respiration also suggests that there is a complex interplay between physical and biological processes in regulating C fluxes. Our study demonstrates that soil physical conditions modulate microbial responses to substrate availability, and that agricultural practices that affect physical conditions can have a significant impact on C dynamics and storage in agricultural soils.

Molecular resistance monitoring of *Helicoverpa armigera* in Australian Bt cotton fields
Amanda Padovan, Kristen Knight, Graham Head, Susan Maas, Sharon Downes, Tom Walsh
Resistance monitoring is a critical part of responsible agriculture, but the bioassay screens currently used are time consuming, labour intensive and expensive. Molecular resistance monitoring tools provide a simpler, cheaper and scalable option for monitoring resistance at the population level. Bayer, CRDC and CSIRO are working together to develop several molecular options which like the bioassays, differ in the types of resistance they detect, and the investment required (cost and time). The major advantages of these molecular methods of resistance monitoring are: (1) Results are generated quickly allowing for management changes throughout the season, and (2) A large database is built that can be screened for new resistance alleles as they are described, e.g. the dominant Cry1Ac resistance detected in China. A more detailed picture of the resistance landscape can be generated by screening large number of samples in space and time. Here we will describe the tools we are developing and show preliminary results on measuring and detecting Bt resistance allele frequencies in *Helicoverpa armigera*. We can detect the known resistance alleles and have identified additional variants that are likely to cause resistance.

KEYNOTE: Computer simulation models as tools for informing insect management
Hazel Parry
Insect pest populations are not contained within a crop field, yet this is the primary scale at which conventional pest management views the problem. A consideration of population dynamics of both pests and beneficials across landscapes allows us to better consider the extent and timing of management options necessary to more effectively control pest populations (often referred to as Area-wide Management, AWM). Understanding what drives the movement behaviour of a pest helps estimate where a population may distribute itself in space and time. Another important factor is the complex structure and dynamics of the landscape itself, something that can be very important in understanding the persistence of pests in time and space yet is often ignored or highly simplified in landscape ecological studies. Computer simulation models are a useful tool in developing an understanding of the landscape ecology of pests and beneficials and can be used to consider multiple pest management scenarios to assist in decision making. Here, I discuss the current AWM challenges posed by insect pests to the cotton industry, and the role that modelling can play in combination with empirical research to gain landscape-scale insights and improve risk management across regions.

Supporting community resilience in the regions

Jana-Axinja Paschen, Margaret Ayre, Ruth Nettle

The resilience of the Australian cotton industry and of communities in cotton regions is currently being tested severely by drought and declining populations. Anticipated changes in energy generation and technology adoption are likely to further impact the future of regional communities. This paper presents research funded by the CRDC in pursuit of a better understanding of community resilience and of how the industry can support resilience in the regions. The meaning, characteristics and practices of community resilience are the subject of lively scientific debate and the formulation of specific policies and actions remains challenging for practitioners on the ground. Resilience approaches are diverse: initiatives may focus on individual mental health, financial and decision-making support, and on developing frameworks that allow assessment of an industry's or community's current capacity to withstand threats and cope with change.
Adopting an holistic understanding of community resilience as the collective capacity to learn, act and adapt in the face of change, this project takes an applied, community-engaged approach to building resilience. The paper presentation explains the main principles of the project's engaged approach and presents key insights from its three case study communities in regional New South Wales (Warren and Walgett) and Queensland (Goondiwindi). As the participatory research project is ongoing until mid-2020, the paper begins to explore opportunities for positive local change as they have begun to emerge from our work with communities to date.

PLENARY: Challenges in Genetic Improvement of Abiotic Stress Tolerance: The ups and downs (mostly downs) of a candidate gene and pathway approach

Paxton Payton and James Mahan

More than two decades have passed since the first commercially successful genetically engineered agricultural crops were launched. These first products were based, in large part, on simple monogenic traits, such as herbicide tolerance or insect resistance that did not require manipulation of complex molecular pathways. Outside of a few recent examples, engineering crops with improved abiotic stress tolerance has proven to be much more difficult. This difficulty is due to the significant number of biochemical interactions driving physiological responses and the wide-range of growing environments and conditions across geographic regions and management systems. One of the biggest challenges for abiotic stress research is to bridge the gap between basic research in model organisms and controlled environments and applied research in crops grown under relevant field conditions. In cotton, as in all genetically altered crop plants, it is ultimately the yield under specific field conditions that determines whether or not a specific gene or signalling pathway is of practical importance. While model systems are critical in elucidating the molecular mechanism by which plants sense and respond to environmental stress, it is essential to evaluate the agronomic value of these discoveries directly in crop plants under "real-world" production scenarios. Additionally, understanding whole-crop responses across a range of production scenarios and locations is critical to target meaningful traits for genetic manipulation. To this end, we have initiated a series of experiments to evaluate crop response to water-deficit and thermal stress across a number of environments to identify the range of phenotypes expressed in rain-grown and irrigated environments with the goal of combining management techniques with genetic engineering approaches to improve cotton yield and quality. The limitations and potential gains from genetic engineering and management will be reviewed here.

Long-term trends in water productivity in the Australian cotton industry

David Perovic, Ben Crawley, Iain Hume, Jasim Uddin, Daowei Sun, Robert Hoogers, Peter Regan, Janelle Montgomery, Guy Roth

Continuing dry conditions across Australia have brought increased public attention to water management and water sharing; as the dominant irrigated crop in many areas, much of this focus has fallen on the cotton industry. While the Australian cotton industry has achieved a 40% improvement in water productivity over a ten year period, between the 1990s and 2000s, this statistic has become outdated. Here we assemble datasets from water productivity studies across the breadth of the Australian cotton industry, dating back to the first extensive studies in the late 1980s to the most recent data from 2018, and compare these with independent and publically available datasets from Boyce and ABS. We use regression analysis and analysis of effect size to provide the most comprehensive picture possible of the long-term trends in water productivity in the Australian cotton industry.

Real-time Nutrient management using Near infrared spectroscopy (NIRS) in cotton

Jeremy Aditya Prananto, Timothy Weaver, Budiman Minasny

The management of Nitrogen in cotton production is reactive due to the lengthy process of petiole collection, preparation, analysis and, if necessary, a prescribed application of nitrogen. The question raised is “can we better manage nitrogen in real-time and thus improve the yield potential?” The current methods are not only lengthy, they are also costly and destructive. Near infrared spectroscopy (NIRS) has been suggested as a real-time, rapid and non-destructive crop nutrient monitoring method that has the potential to replace current traditional wet laboratory methods. However, field NIRS application is still restricted due to external limiting factors that prevent the development of robust calibrations.

This research reported researched the development of NIR calibrations that will be used to assess the viability of NIRS to accurately estimate the macro- (N, P, K, Ca, Mg) and micronutrients (Fe, Mn, Zn, Cu) status in plant leaf tissues (Cotton as a model crop due to funding and availability). Moreover, this research aims to investigate and establish a transfer function that can translate a calibration that is suited for standard laboratory application into one that is suitable for field application. Thus, with the establishment of this transfer function, there is a great potential for the field application of NIRS to be used for in-situ nutrient analysis of plant leaf tissue that will allow nutrient management to be proactive and not reactive. Thus, improving the yield potential in the cotton industry.

Bacterial consortia reduce severity of Fusarium wilt in cotton

Zhiguang Qiu, Jay P. Verma, David T. Tissue, Brajesh K. Singh

Soil bacteria colonise plant roots and interact intimately with their plant host. Some colonisers promote plant growth and may also exhibit antagonistic activities against pathogenic microorganisms. However, most of the studies used single species as biocontrol products, and only few studies have attempted to use a consortium which can arguably have better ability to survive in new environment and hence improved efficacy.

The cotton wilt is a major constraint of cotton farm productivity in Australia. To develop better plant fitness and agricultural sustainability, we aim to isolate multiple bacterial species and to develop a bacterial consortium which demonstrated antagonistic activities against Cotton Fusarium Wilt disease caused by *Fusarium oxysporum* f.sp. *vasinfectum* (Fov). We tested if applying the bacterial consortium could positively change cotton microbiome and improve control of Fusarium wilt. In this study, we tested whether a consortium could provide a better control of pathogen and if the efficacy of biocontrol agents is modified by cotton cultivars. A number of antagonistic bacteria were isolated from the roots of healthy cotton plants and a bacterial consortium was developed based on their ability to grow together with synergistic relation. Our results showed that bacterial consortia improved seed germination by 50% but the impact of disease incidence was modified by crop cultivars. Specific patterns of microbial assemblages were observed in symptomatic vs. asymptomatic crops. Interestingly, the plant microbiome in rhizosphere were also driven by both bacterial consortia and Fov, while no significant difference found in bulk soil.

Overall, our results demonstrated that biocontrol agents are effective in reducing disease incidence under glasshouse conditions with two different soils, and plant microbiome can be driven by both bacterial consortia, presence of Fov and disease symptoms.

Poultry Litter Fertilizer Effects on Cotton Yield and Lint Quality in South Eastern Australia

Wendy Quayle and Anika Molesworth

Cotton growers are applying readily available poultry litter (PL) year on year to cotton growing land in The Riverina region of NSW primarily for the potential it may offer to longer term soil health and sustainability. Usually, the valuable sources of plant nutrients that PL contains is not being integrated into cotton nutrient budgets due to performance uncertainties caused by product variability. Thus a field study was conducted on a Riverina Clay soil type; red and grey hard setting clays, to compare poultry litter as an N source with conventional urea-N from 2018-2019. Nitrogen fertilizer sources evaluated included urea-N as the farmer practise (FP) and integrated proportions of urea with poultry litter to meet matched N rates; 30 % poultry litter-N:70% urea-N (PL:U 30:70); 70% poultry litter N:30% urea-N (PL:U 70:30); 100% poultry litter-N (PL 100) and an unfertilized control (Zero). Generally, cotton lint yields were similar in the first year but tended to slightly increase in the second year between the traditional fertilizer programme and the treatments comprised of PL. The effect of how nutrient source affected fibre quality, the variation between years and the impact on discount/premium values are discussed. Were PL to be of a low enough price, it could become a viable alternative fertilizer source within 2 year cotton rotations, in addition to offering possible long term soil health benefits.

The interwoven impacts of Bt maize, Bt cotton, and soybean on *Helicoverpa zea* in the United States

Dominic Reisig, Lewis Braswell, Sebe Brown, David Kerns, Fred Musser, Francis Reay-Jones, and Fei Yang

Plant incorporated Bt toxins have successfully managed many lepidopteran pests in the United States for over 20 years. One species, *Helicoverpa zea*, has developed resistance to the Cry toxins in both maize and cotton in the southern US. As a result, in cotton expressing only Cry toxins, growers are relying on foliar oversprays of a single insecticide, chlorantraniliprole. Furthermore, while the plant incorporated VIP toxin has been introduced as a pyramid to some maize and cotton cultivars expressing Cry toxins, this is essentially a single mode of action, since there is resistance to Cry toxins. Maize is thought to be the primary driver in the system placing selection pressure on VIP, while soybeans are thought to be the primary driver in the system placing selection pressure on chlorantraniliprole. Both experimental and observational evidence suggest that *H. zea* is evolving resistance to VIP. Although true baselines were not established before the commercialization of VIP and chlorantraniliprole, current toxicity data suggest that *H. zea* have a range of susceptibility to VIP and that this toxin is expressed in plants at a moderate dose. In contrast, *H. zea* is still well controlled by chlorantraniliprole. In conclusion, we suggest changes in management to delay the development of resistance of plant incorporated Bt toxins as well as chlorantraniliprole for *H. zea*, including restricting the use of insecticides in maize and soybean and the need for studies to evaluate the role of cultural tactics, such as cover crops and tillage.

KEYNOTE: Quantifying the potential environmental risk of pesticides used on cotton farms

Michael Rose, Francisco Sanchez-Bayo, Guna Nachimuthu, Stacey Cunningham, Brad Keen, Stephen Kimber, Lukas Van Zwieten

The spectrum and quantity of pesticides used in the Australian cotton industry has changed dramatically over the last 20 year with the adoption of GM cotton cultivars and best management practices for insecticide, herbicide and fungicide use. However no recent studies have been conducted to determine how these practice changes have affected the environmental risk posed by pesticides used in the cotton industry. In this work we quantified the change in relative risk of cotton pesticides over the last 20 years using two different methods. We found that total environmental toxic load (ETL) scores have significantly decreased by 2–5 times since 1999, depending on the environmental compartment under examination. We also ranked and identified those pesticides with the highest relative risk profile to different environmental compartments. Based on this assessment, we monitored the concentrations of 15 different pesticides used in cotton production that exhibited relatively elevated ETL scores, and some additional herbicides not used in cotton, across three different cotton growing catchments: the Barwon, Namoi and Murrumbidgee. Nine of the 15 pesticides were detected at least once in monthly grab samples from 21 different sites (Sep 2018–May 2019), with the herbicides atrazine, simazine and diuron detected in more than 30% of samples. Nevertheless the levels of these and other pesticides are generally lower than those found in previous studies between 10–20 years ago, and are below common ecotoxicology thresholds. Ongoing monitoring and risk assessment will seek to better understand the drivers of off-site pesticide movement and identify potential practices to minimise the environmental impact of pesticides used in cotton production.

Strategies for reducing N runoff from furrow-irrigated cotton cropping

Graeme Schwenke, Gunasekhar Nachimuthu, Jon Baird, Ben Macdonald, Annabelle McPherson, Clarence Mercer, Andy Hundt

Runoff of nitrogen (N) in tail-water may constitute a significant N loss from the target cotton paddock, while dissolved phosphorus (P) runoff is unknown. N in runoff is sourced from (a) irrigation water, (b) pre-plant or side-dressed banded fertiliser, (c) in-crop surface-applied fertiliser and (d) fertigation (water-run N). P in runoff comes from (a) and (b), as well as the paddock soil. Over three cotton-growing seasons (2016–7, 2017–18, 2018–19), we compared N and P runoff from replicated and randomized field-length plots of: N fertiliser products (including enhanced efficiency fertilisers); P fertiliser; N rates; N application timing; and N fertiliser placement options at the Australian Cotton Research Institute, Narrabri.

Seasonal inputs of N (nitrate + ammonium + urea) in irrigation water ranged from 4–38 kg N/ha. Total irrigation water applied to the three experiments was similar (8.9–9.5 ML/ha), but the proportion of applied water running out of the paddock totalled across each season varied from 16–42% of that applied due to antecedent soil moisture, crop water use and in-season weather. The water runoff proportion had a large influence on the quantum of N (and P) runoff each year.

High pre-plant N rates increased runoff N loss in 2017–18 and 2018–19, but not 2016–17. N loss from pre-plant or side-dressed urea occurred through lateral movement of nitrate from the plant bed into the "skip" row, mostly during the first two irrigation events. Measurable urea and ammonium were also found when irrigation occurred soon after fertilising. Applying pre-plant N as polymer-coated or nitrification inhibitor-coated urea reduced N runoff by up to 50%. Seasonal total N runoff was reduced by applying more/all N fertiliser in-crop, either by broadcasting or side-dressing urea. Highest N runoff occurred when in-crop N was water-run, particularly when a high proportion of the applied water exited the paddock. Ceasing fertiliser N addition to the head-water once runoff began proved effective at decreasing N runoff.

Dissolved P accrued in the paddock (inflow P > runoff P) during the 2016–17 (343 g P/ha) and 2018–19 seasons (377 g P/ha). In 2017–18, there was a net negative P balance (-132 g P/ha), due to a higher runoff coefficient and higher P inputs in irrigation water. The pre-plant application of P-fertiliser in 2017–18 and 2018–19 increased P runoff but the paddock P-balance in 2018–19 was still positive. Urea application reduced dissolved reactive P losses in the 2017–18 and 2018–19 seasons.

Evaluating the use of pheromone traps to monitor mirid populations

Elizabeth Shakeshaft

Green mirids have the potential to reduce cotton crop productivity throughout the season from early squaring to boll fill. Currently mirids are monitored in the field once or twice a week using a beat sheet or sweep net. This process is time consuming and results can vary over the course of the day. New novel methods of mirid monitoring, including pheromone and light traps, are currently being evaluated for their efficacy and viability in cotton production systems.

This study involved four pheromone traps placed in cotton fields in southern New South Wales for the duration of the 2018–19 season. Mirid populations were monitored traditionally in the same fields and compared with the findings in the pheromone trap with the purpose of understanding any potential correlation between the trap findings and the industry standard methods. Ideally, the outcome would lead to easier and more efficient monitoring of mirids, which in turn would assist with sampling techniques, allowing growers and agronomists to be more privy to mirid populations in real-time, and aid in pest management decisions.

After one season of observation, there have not been any strong correlations between pheromone trap captures and traditional bug checking methods. This year the study will look at more sites and utilise local weather station data to see if the spikes in mirid populations can be predicted. My presentation will cover results to date, challenges, successes and plans for repeating the study this season coming.

Surveillance for endemic and exotic virus diseases in northern Australia and Timor-Leste

Murray Sharman

Several surveys for virus threats were done in northern Australia and Timor-Leste from 2016–2018. Samples were testing during surveys and also returned to Australia under quarantine permit for further lab testing for poleroviruses. Cotton leafroll dwarf virus or CLRDV (the causal agent for cotton blue disease) has now been detected in *Gossypium barbadense*, *G. arboreum* and *G. hirsutum* in Timor-Leste in many locations across the country and has also been found in ornamental hibiscus. These *Gossypium* species were only present in very low numbers but the virus was present in greater than 25% of *Gossypium* plants tested.

During surveys in Timor-Leste, at least another three new polerovirus species were found in various host species. A couple of these aphid-transmitted polerovirus species were also detected in northern Australia, suggesting a wind-borne pathway for aphids may exist between Timor-Leste and Australia. Such a pathway may change the risk profile for a possible movement of Cotton leafroll dwarf virus, or other insect-borne threats, into northern Australia which is of particular interest with the expansion of cotton production in far northern regions.

Nested RT-PCRs for the open reading frame 0 (ORF-0) and ORF-3 of CLRDV have been developed based on the known virus diversity from Thailand, Timor-Leste, South America, Uzbekistan and India. Partial sequence of the ORF-0 gene of Cotton leafroll dwarf virus (CLRDV) from samples across Timor-Leste, Thailand and Uzbekistan has demonstrated there is a greater genetic diversity of CLRDV from samples collected from neighbouring valleys of Timor-Leste than there is from reported samples from South America. This may have implications for pathway risk analysis and the likelihood that resistance-breaking strains may exist within the SE-Asian population of CLRDV.

New synthetic biology opportunities to build climate adapted germplasm

Robert E. Sharwood

Finding new solutions to combat future changes in climate has stimulated new cotton pre-breeding efforts to screen for diversity in photosynthesis to provide new solutions for increasing CO_2 assimilation under hotter and drier climates. Maximising photosynthetic efficiency is pivotal for increasing plant productivity by: 1) increasing the flux through the Calvin cycle by altering Rubisco (ribulose-1,5-bisphosphate carboxylase / oxygenase) together with its metabolic repair enzyme Rubisco activase and 2) maximising the capture and utilisation of solar radiation to power carbon assimilation. The lack of variation in Rubisco catalytic performance among elite cultivars has augmented new effort to interrogate the diversity of Rubisco catalytic performance among wild cotton relatives. We discovered changes in Rubisco performance under elevated temperatures and guided by structure-function analyses and new SynBio innovations in Rubisco engineering, we will pinpoint the amino acid residues conferring this catalytic phenotype.

Environmental footprints of cotton production; not a case for change

Aaron Simmons and David Perovic

All agricultural production has negative impacts on the environment, but the global population could not exist without agriculture. This means that these impacts are necessary but it does not mean that the impacts associated with agricultural production should not be minimised. Environmental footprints (e.g. carbon, water) have been extensively used to quantify the environmental impacts of cotton production. These footprints have also provided a basis for environmental groups to call for a reduction in Australian cotton production. Environmental footprints, however, are not a useful way to inform practice change, and reduction in Australian cotton production may actually increase environmental impacts! This may occur for either of two reasons. Firstly, the land and water previously used to produce cotton would now be used to produce other crops, as farmers still need to make a living. Secondly, the cotton not produced in Australia would need to be displaced by cotton grown elsewhere or replaced with other fibres, potential synthetic fibres, as the global demand for fibres would not change. This presentation will provide an understanding of the key processes that need to be included when assessing the consequences of ceasing Australian cotton production. It will also provide results from a consequential life cycle assessment on the environmental consequences of reducing irrigated cotton production in Central NSW.

Prevalence and distribution of cotton diseases in 2018/19 season

Linda Smith, Linda Scheikowski, Dinesh Kafle, Duy Le, Aphrika Gregson, Tim Green, Sharna Holman, Kieran O'Keeffe, Amanda Thomas, Elsie Hudson, Janelle Montgomery, Andrew McKay and Annabel Twine

Cotton is susceptible to many yield-limiting diseases. To understand the importance of diseases present, surveys are conducted to monitor disease distribution and incidence. Surveys also maintain the surveillance for exotic pathogens. Historically, surveys were undertaken separately within NSW and QLD. This project takes a new approach, bringing together data across the industry in a national project. Different regions are being affected by different pathogens. Black Root Rot is a limiting factor in southern NSW. The highest incidence this season was in the Gwydir; however severity was mild, as indicated by less than 15% of the taproot surface being blackened. Alternaria leaf spot is rising as an early season disease of concern in NSW. Mean disease incidence (MDI) of seedlings infected was 59%, 23% and 21.5% in the Gwydir, Namoi and Murrumbidgee respectively; however disease severity was low. Fusarium wilt remains a key disease for St George and Darling Downs, detected in 50% and 65% of fields surveyed early season. A high incidence was detected in fields late season in St George, Darling Downs and Macquarie. There was likely an impact on yield for some fields. Verticillium wilt continues to be a major disease of concern in the Border Rivers and Namoi, with a MDI of 21.5% and 20% respectively. On the Darling Downs, MDI was low; however an incidence of 71% with severe symptoms was recorded. In the Gwydir, 30% of fields surveyed had both wilt diseases. This poses a major challenge in managing crop residues, crop rotations and cultivar selections to minimise disease impacts. The surveys also served as a vehicle for the collection of soil for analysis of plant-parasitic nematodes. New farms in Emerald were confirmed to have reniform nematode, which to date, has only been detected in cotton in CQ. Results demonstrate the necessity of multi-pest surveillance systems in cotton in providing an ongoing evaluation of the distribution and impact of key endemic pests.

PLENARY: Cotton doesn't grow on trees, but ecosystem services do!

Rhiannon Smith

Native vegetation provides a range of benefits, termed ecosystem services, to cotton growers and the wider community. Examples include carbon (C) sequestration, erosion mitigation, biodiversity conservation and natural pest control. These ecosystem services can be worth billions of dollars in: (1) product promotion (e.g. for carbon neutrality and environmental footprints); (2) tradable assets (e.g. carbon and biodiversity offsets), and (3) avoided costs (e.g. pesticide use). Measuring biodiversity and ecosystem service provision on cotton farms and informing cotton growers about the value, management and restoration of native habitats on-farm for biodiversity conservation and ecosystem service provision have been central themes in my research and that of my students over the past 14 years. This presentation will explore some of the findings of that research and future directions for ecosystem service research in the Australian cotton industry.

Recruitment of *Helicoverpa* pupae in the Central Highlands: where are they coming from?

Gail Spargo, Sharna Holman and Paul Grundy

Helicoverpa spp. population dynamics in the Central Highlands were examined by Sequeira (1996) to test assumptions underlying strategic trap cropping programs. This study found continuous recruitment of pupae within the farming system with cotton and chickpea crops identified as major host crops. 20 years after the completion of this study, we have repeated this work to ascertain the impact of several major changes within the local farming system on *Helicoverpa* abundance and recruitment. Sampling results from the past two seasons have shown major changes in both the abundance and recruitment of *Helicoverpa* in the local farming system. Chickpeas which were once a major source of pupae (10,000 to >100,000 pupae/ha) now record far fewer pupae (<500 ha) due to the advent of highly efficacious insecticides with alternate modes of action and higher commodity prices that have greatly reduced economic control thresholds. Likewise the advent of Bollgard 3 cotton varieties has changed this crop from being a major source (up to 100,000 pupae/ha) to a landscape level sink (0 pupae/ha). Pigeon pea refuges and minor grain crops within the irrigated farming season would appear to be the primary host crops for *Helicoverpa* recruitment in the Central Highlands albeit during unseasonably dry years. From an RMP perspective, the CQ farming system would appear to be heavily dependent on refuges for the production of susceptible individuals for the purpose of diluting resistance alleles within the local population. In this presentation, we will share the findings of our sampling program and discuss the implications that this might have for both the Bollgard RMP and insecticide resistance management.

Developing Diverse Capability
Trudy Staines
What has the Cotton industry been doing about developing capability? Why is it important to maintain our level of engagement even in a drought? As an agricultural industry we are faced with the challenges of skilled labour shortages, low retention, an ageing workforce, and competition from other sectors such as mining and other agricultural industries. We are also suffering low attraction rates on farm as well as into research roles. On top of this we are enduring a drought. For over 10 years CRDC, Cotton Australia and CSIRO have been collaborating to help address these issues. Our initiatives attracted agriculture and science students to our industry with programs and activities that engage primary, secondary and undergraduate university students, and improved the supply of suitably qualified professional personnel to help make the cotton industry an employer of choice. Now we need to take our cotton to new heights and challenge our diversity of thinking to adapt to changes in markets, technology, water shortages and succession planning for researchers. We would like to increase the diversity of capability and thinking available to agricultural businesses with students from a greater range of academic backgrounds not just agricultural students.

KEYNOTE: Breeding, traits and the future: Perspectives from an optimistic pessimist
Warwick Stiller
At the core of germplasm enhancement and breeding is the identification, selection and incorporation of genetically controlled traits of value into a commercial cultivar. The CSIRO cotton breeding program has had clearly demonstrated gains over a long period of time, evidenced by the release of cultivars with sustained improvements in yield, fibre quality and disease resistance. These cultivars have underpinned the continued yield and fibre quality gains the industry has been able to achieve. This presentation will define current and future trait targets and describe how they are incorporated into elite cultivars. We will explain how traits are prioritised within the program and the complexities of incorporating multiple GM, agronomic, disease resistance, arthropod resistance, seed quality and abiotic stress tolerance traits into an elite cultivar. Importantly, this must also be matched with what is realistic in terms of impact and timelines. To highlight this, several case studies will be presented. Conclusions will be drawn around the future direction of cotton breeding, the technologies that will assist breeders into the future and how likely it is for breeding to sustain the previously observed gains with an increasing number of target traits.

Improving water productivity in the Australian cotton industry—mapping the challenges for systemic interventions
Daowei Sun, Ben Crawley, Peter Regan, Iain Hume, Jasim Uddin, David Perovic
Water has become one of the most limiting resources for Australian agriculture. Cotton is one of the dominant irrigated crops and the industry is regularly under pressure to justify its water use. In this presentation, we will outline the opportunities that a Systems Thinking approach can provide in (1) demonstrating how Australian cotton businesses have been striving to improve their water productivity and stewardship, and (2) identifying further opportunities for improving water productivity. The Systems Thinking approach embraces a holistic view while unlocking the complexity and dynamics of related issues by incorporating multiple perspectives of key stakeholders. During this process, the much broader natural, social and economic environments in which these issues are embedded will also be taken into consideration. Barriers to improving water productivity in the Australian cotton industry will be identified for systemic interventions.

Building a knowledge framework to engineer cotton fibre morphology
Makoto Yanagisawa, Samy Belteton, Sedighe Keynia , Joseph A. Turner and **Daniel B. Szymanski**
Cotton is a unique crop in that its value arises from the growth behaviours and mechanical properties of individual and highly polarized cells that emerge from the developing seed coat. Important fibre traits like length, diameter, and twist are programmed by complex interactions between cellular transport, cytoskeletal, and cell wall synthesis systems. It is therefore possible to engineer these cellular systems to specify fibres with novel or improved traits with increased value. This is a tall order to fill. There are major gaps in our knowledge base that preclude rational engineering strategies. We don't understand how cellular scale transport systems assemble and rearrange during growth to generate reproducible morphogenetic outputs. Similarly, the assembly mechanisms and mechanical properties of the tough outer cell wall that ultimately defines the shape change of the cell are poorly understood. This seminar will describe a novel approach to fibre trait engineering in which the combined use of genetics, multi-variate live cell imaging, and finite element computational modelling is used to analyse the how complex cellular systems interact to control cell morphogenesis1. Finite element modelling treats the plant cell wall as a thin-walled pressurized shell, and makes testable predictions about what wall properties are needed to generate specific growth outputs. The method capitalizes on the experimental power of the Arabidopsis and the single cell system of cotton fibres, and provides a new way to analyse morphogenesis across wide spatial scales. This approach is enabling discoveries about how cell geometry, cell wall tensile stress, and cytoskeletal systems feedback on one another during morphogenesis. Data will be presented that demonstrates the feasibility of engineering cotton fibre diameter and fibre twist upon desiccation.

PLENARY: A Researcher's Odyssey

Ian Taylor

The word 'odyssey' is derived from the Ancient Greek, Odusseía, the story of Odysseus, an epic poem consisting of some 24 books written by Homer. The poem recounts the return journey of Odysseus to the island of Ithaca over a ten-year period, and describes the various trials, distractions, and challenging decisions that he had to make. When he finally arrives at Ithaca rather than a fairy tale ending he finds that there is more he has to endure, young men from a nearby town have invaded the island are putting pressure on his wife Penelope to marry one of them. Odysseus, famed for his courage, intelligence and leadership was a deep thinker and innovator - the Trojan horse was his idea. His capacity for inventive thought proved crucial to the eventual success of the Greeks in the war against the Trojans and while he was side-tracked on a number of occasions he demonstrated his commitment both to family and to a higher value cause.

Successful Researchers, Development and Extension specialists possess similar character attributes as Odysseus. They require courage to challenge both the unknown and existing paradigms, the ability to lead change and provide an understanding why practices should and need to change based on scientific understanding, to think deeply on issues at a systems level and to develop innovative solutions to address the challenges of a "modern agriculture". Climate change, drought, limited water, social licence, transparency and provenance traceability require new approaches to farming and the application of new technologies. Society and consumers have much greater expectations of farming and farmers than perhaps in previous generations, and the conversation has shifted from one of knowledge to one of values. As Deanna Lush states in her essay *The right to farm verses the right to choose: society is having the final say*, the right to farm debate is not focused on knowledge, but whether we should be doing what we are doing.

Can Managed Aquifer Recharge (MAR) increase water security for cotton production?

Jenifer Ticehurst, Willem Vervoort, Andrew Ross, Ignacio Fuentes, Tony Jakeman, Joseph Guillaume and Barry Croke

The cotton industry has actively adapted crop management, such as increasing water use efficiencies, to address pressures in water availability. Yet the industry is still criticised. With an uncertain future climate and the potential for further policy changes to water entitlements, water security has become a key limiting factor in the profitability of the industry.

Managed Aquifer Recharge (MAR) is the purposeful recharge of aquifers using surface water, which can be extracted at a time when required. Interest in MAR is continuing to grow in Australia. MAR schemes offer an option to store available surface water underground and therefore avoid evaporative losses that can be experienced when storing water above ground. This supplementary water supply can even out the peaks and troughs, leading to greater security and certainty in irrigated cropping. However, MAR systems can be expensive to implement and are also subject to technical and financial uncertainties, such as aquifer recharge and recovery rates and costs. Therefore, there is a need for guidance as to when and where MAR might be a feasible option. This research investigates the potential to implement MAR at a regional scale in three irrigated cotton growing regions of Australia (The Murrumbidgee, Namoi and Gilbert catchments). The feasibility of MAR in these areas will be evaluated across all facets (i.e. financial, technical, legislative, social and environmental). Findings to date will be presented including the general technical and financial feasibility of different types of MAR schemes, and an overview of policies that enable, or are barriers, to implementing MAR.

The importance of flowering to *Helicoverpa armigera* and *H. punctigera* survival on pigeon pea

Ethan Towns and Mary Whitehouse

Helicoverpa punctigera and *H. armigera* are significant pests in Australian cotton fields that are largely controlled by Bt cotton. To slow the evolution of resistance to Bt cotton in these pests, the Resistant Management Plant (RMP) was developed. One tool in the RMP is to use non-Bt refuge crops, such as non-Bt cotton and pigeon pea, to produce susceptible moths that have not been exposed to Bt toxins to dilute the effect of resistance moths. The assumption is that the larvae would develop equally well on pigeon pea as they do on cotton. However, pigeon pea often flowers a month after cotton. If *Helicoverpa* cannot develop as well on non-flowering pigeon pea as they can on flowering cotton, then the RMP could be compromised early season.

We tested if *H. punctigera* and *H. armigera* could develop equally well on non-flowering pigeon pea as they do on flowering cotton. To do this we reared larvae from laboratory colonies on an artificial diet until 3rd instar, at which point they were transferred to either the top section of non-flowering pigeon pea (non-fl ppea) plants, or flowering non-Bt cotton (fl cotton) plants, where they were maintained until they pupated. The results showed that *H. armigera* survived equally well on non-fl ppea and fl cotton, and that they matured significantly faster on non-fl ppea; while *H. punctigera* matured at the same rate on fl cotton and non-fl ppea, but survived significantly better on fl cotton. These results show that while *H. armigera* is able to develop and survive well on non-flowering pigeon pea, *H. punctigera* is not. For *H. punctigera*, flowering non-Bt cotton is a more reliable refuge than non-flowering pigeon pea. This means that pigeon pea when it is not flowering it is a good refuge for *H.armigera*, but not for *H. punctigera*, potentially compromising the RMP for *H. punctigera*, particularly early season.

Cotton that is unpalatable to spider mites: from dream to reality

Carlos Trapero, Elodie R. Tanner, Iain Wilson, Qian-Hao Zhu, Lewis J. Wilson, Warwick N. Stiller

The two-spotted spider mite (*Tetranychus urticae*) is an important pest of cotton. It feeds and causes substantial damage on the leaves, often leading to a significant reduction in the yield and the quality of the fibre. Spider mite outbreaks are usually controlled by chemical applications, but this is problematic due to the cost as well as the selection for pesticide resistance within mite populations. Our research aims to develop new cotton cultivars with a high level of resistance to this pest, which would require fewer pesticide applications. Sources of resistance from three different *Gossypium* species are being used to generate elite germplasm with high level of resistance. A large number of genotypes are generated in each backcrossing phase, and then resistant individuals identified by screening using spider mites in a glasshouse bioassay. Additionally, the development of molecular markers is also underway to assist in accelerating this selection procedure. We have identified that spider mite resistance in cotton is provided by two main genomic regions, and recently quantified the individual specific contribution of each one of them to the resistance under different environmental conditions. Selected breeding lines have been developed that combine a high level of field resistance to spider mites with acceptable yield, suggesting that spider mite-resistance commercial cultivars could be generated in the near future.

I had an electromagnetic dream and it is slowly coming true

John Triantafilis

In the early 1990's incipient traces of soil salinity were becoming apparent in many irrigated areas. As a consequence, a research project emanating from the University of Sydney and in the guise of various CRDC, Australian Cotton CRC and Natural Heritage Trust Projects was devised. In this presentation, a brief history on the project, entitled "Understanding the salinity threat" and the various Phases; I (Methods and Techniques), II (Data Collection), III (Modelling and Mapping), and IV (Interpretation and Management) is provided. Whilst formerly completed in terms of funding in 2004, the data has been used to publish research papers in the area of Digital Soil Mapping, Proximal Soil Sensing, Precision Agriculture, Natural Resource Management and using a wide variety of Pedometrics techniques. This has been done mostly out of UNSW Sydney. The data has been used to map soil salinity, but related properties such as cation exchange capacity, available water content, particle size fractions and pH. The maps developed at the district scale, across seven cotton growing areas) can be viewed at terraGIS (http://www.terragis.bees.unsw.edu.au/). The data which underpins these maps, include proximal sensed electromagnetic induction instruments including the rootzone (e.g. EM38) and vadose zone measuring (EM34) instruments, but also air-borne gamma-ray spectrometry data. Since this time, smaller scale projects, using newer techniques (e.g. inversion modelling using EM4Soil) and state of the art EM instruments (DUALEM-421) have been used to map these soil properties and more (i.e. soil water dynamics) in 2-d and 3-d. The methods used and results achieved are briefly described as too will the practical management implications.

Are ETc and crop coefficients similar in solid and skip-row cotton planting configurations?

Jasim Uddin, Joseph Foley, Simon Kelderman

Australian cotton growers often use a variety of skip-row planting configurations in irrigated cotton when water is limited. There has been extensive Australian research focussed on yield and fibre quality outcomes across different planting configurations. Accurate comparisons of measured water use in irrigated cotton under different planting configurations are still lacking. Crop coefficients (Kc) used in standard crop evapotranspiration analyses directly impact crop water use results and resultant irrigation requirements, and coefficients for single skip-row planting configurations are also lacking. The objective of this study is to compare the crop water use and crop coefficients for solid (1 m rows) and single skip-row (2 in, 1 out) planting configurations in irrigated cotton. An investigation of these two configurations was conducted at a cotton farm at Waverley, Wee Waa, NSW during two summer cotton growing periods from 2016 to 2018. Cotton evapotranspiration (ETc) was estimated using advanced eddy covariance (ECV) method, and the crop coefficient was calculated by using reference crop ET estimated by the FAO 56 Penman-Monteith method. The 2017–18 data for the single skip-row shows that ETc from ECV was slightly less (avg. 6.3 mm/day) during the mature stage compared to results from FAO56 PM standard method (avg. 7.0 mm/day). Data analysis highlights that the fitted Kc was less (avg. 0.95) for the mature crop stage in single skip-row configuration than the standard value (1.15) selected from FAO56 PM for solid planting, and greater than the 0.77 that could be expected for single skip-row planting configurations. The 2016-17 solid configuration data show that the ETc and Kc values were very similar for both estimation methods under a solid planting configuration. The reduced water use in skip-row field was still higher than expected for cotton in skip-row configurations, and may be due to the higher soil evaporation from irrigated bare earth rows.

KEYNOTE: Harnessing beneficial microbiomes in cotton systems

Vadakattu V.S.R. Gupta

Plants are in intimate contact with microorganisms, both inside and outside of plants, which perform many beneficial functions related to nutrition, disease control, promotion of plant growth and tolerance to abiotic stresses. Recent knowledge and the growing appreciation of the genetic potential and functional importance of the soil and plant microbiomes present a valuable opportunity to better harness beneficial microbiomes towards economic and environmentally sustainability in current and future Australian cotton systems.

Modern metagenomic tools allow exploration of all aspects of microbiomes in terms of phylogenetic and specific functional communities. The *omics* based tools when integrated with culture-based techniques can help identify the hidden species-level diversity and their functional potential to better harness beneficial functions through management and plant breeding.

Soil microbial community composition and their functional capacity varies across gradients of environment and soil characteristics and can be modulated through management in agricultural systems. Within a soil type, management practices including fertilizer and chemical application and plant / cultivar type can exert significant selective forces on microbial diversity, shaping and restructuring rhizosphere and endosphere microbiomes. Recent research indicates that the diversity of soil fungal communities varied between different cotton growing regions and a region specific soil fungal community assembly exists. Crop rotation practices such as fallow-cotton and continuous cotton can reduce microbial activity, catabolic potential, diversity of bacterial and fungal communities and abundance of plant growth promoting bacteria compared to rotations with maize and sorghum. Furthermore, previous evidence for cultivar based variation in the rhizosphere microbiome highlights the potential to improve beneficial microbial functions in Australian cotton farming systems through targeted management and cultivar development.

The effect of harvesting on fibre and seed quality

M.H.J. van der Sluijs

It has been stated that mechanical harvesting has had the greatest impact on cotton since the invention of the cotton gin and plays an important role in determining fibre and seed quality, as the quality of ginned cotton is directly related to the quality of seed cotton prior to ginning. Irrespective of which mechanical harvesting method is used, the set-up and adjustment, training and skill of the operators, as well as the timing of defoliation and harvesting play a major role in the amount of trash and moisture present in the seed cotton. The efficiency of harvesting and the resultant fibre quality can be influenced by many factors and studies were initiated to investigate the consequence of seed cotton moisture, spindle speed, as well as row unit factors, such as picker drum arrangement, compressor plate pressure, as well as scrapping plates.

Several studies were conducted which showed that seed cotton harvested; 12% resulted in significant differences in processing performance, gin turn out, micronaire, colour, trash, seed-coat neps and nep size, with the seeds not able to be used for germination. In terms of machine set-up, ground speed and back compressor plate pressure setting had little or no effect on fibre quality. However, front compressor plate settings and the addition of scrapping plates resulted in improved colour grade, nep and trash content and an increase in fibre length, strength and micronaire and a decrease in elongation. It was also noted that mechanical damaged seed levels increased as the front and back compressor plate pressures were increased. Drum arrangement had little or no effect on fibre quality.

Production of fermentable sugars and bioethanol from cotton gin trash

Tony Vancov, Janice Palmer and Brad Keen

Cotton is a significant broad acre crop in Australia, with more than half a million hectares under cultivation. The process of ginning cotton to produce fibre generates up to 230,000 ton of cotton gin trash (CGT) annually and strategies to manage CGT as a waste material vary but each adds considerable cost to the ginning process. This combined with increasing disposal fees, stricter regulations on environmental applications and emissions and higher fuel prices, is driving interest in transforming CGT into a value-added material by diverting it toward utilisation as a biorefinery feedstock. Like most lignocellulosic material, conversion of CGT to sugars for ethanol fermentation entails a pretreatment step to minimise structural hindrance during enzyme hydrolysis. Regardless of the approach taken, most pretreatments focus on isolating cellulose fibres to the detriment of hemicellulose sugars. However, recovery and use of all sugars from CGT is vital for the economic realization of lignocellulosic ethanol. Within this context, this presentation outlines the development of a pretreatment and fermentation process for CGT arising from the Rural R&D for profit "Biorefineries for profit" programme. A sequential pretreatment process was judiciously designed wherein stage 1 yielded pentose-laden liquors for yeast propagation and predicated operational parameters for stage 2 digestible fibre production. Progressive appraisal of fibre hydrolysis and fermentation approaches hastened process-step consolidation, culminating in successful pilot scale validation trials at the Mackay Renewable Biocommodities Pilot Plant. Results from laboratory and pilot scale trials indicated conversion efficiencies of up to 80.6% with a potential minimum ethanol yield of 115 L t^{-1} raw CGT.

Natural capital assets of the cotton landscape of eastern Australia and management strategies to enhance them

J. P. Wall

Improving knowledge about natural systems in the cotton landscape will provide industry with a better evidence-base from which to set objectives and prioritise actions for natural capital enhancement via whole-of-industry management. This paper presents a snapshot of key biodiversity assets across the cotton growing regions of NSW and Queensland, and uses these data to identify places in the landscape that would benefit most from efforts to protect and restore natural capital assets.

Spatial data are compiled from various Government sources and include: vegetation extent, type, diversity, condition and intactness; landscape corridors; public land reserves; rivers and streams; natural and artificial wetlands; and threatened and iconic plant and animal species. These data are applied to a prioritisation framework linked to GIS that identifies areas in the cotton landscape most suitable for long-term restoration and revegetation projects.

Data compiled at the landscape scale are then showcased within cotton growing regions based on Local Government Areas. A total of 36 regions are delineated and for each region a profile is established that: (1) provides an overview map; (2) lists key biodiversity assets; and (3) lists a set of generic and region-specific management actions that focus on the habitat requirements of the particular assemblage of species represented in that region.

Each profile is designed to increase the knowledge base about biodiversity assets in cotton growing regions and to stimulate further action to ensure that remnant bushland on and adjacent to cotton farms is retained, enhanced and augmented for the benefit of all native plant and animal species, for a healthy landscape, and for a sustainable industry.

CRISPR/Cas9 modification of Lepidoptera for basic research, understanding resistance and future genetic control

Tom Walsh, Bill James

Genetic modification tools are revolutionising our understanding of non-model systems. The clustered regularly interspaced short palindromic repeats (CRISPR)/Cas system has been co-opted from its role in bacteria as a defence against viruses to be an RNA-mediated nuclease for use in targeted genome engineering. These tools provide new approaches to manipulate insect genomes, understand the function of genes and allow us to introduce variation identified in the field into experimental systems.

Helicoverpa armigera is one of the most significant pests of agriculture across Asia, Africa, Australia, Europe and more recently South America. As well as a wide host range*, H. armigera* has developed resistance to almost all the pesticides used to control this species. In Australia, since 1996, genetically modified cotton containing insecticidal proteins from *Bacillus thuringiensis* has been introduced and been very successful in controlling this pest. However, elsewhere around the world, resistance has developed. In this talk we will discuss the potential of this technology and present some early results using the tool in *H. armigera* to investigate Bt resistance mechanisms. In the future, these approaches may allow genetic control of populations, the removal of traits from wild populations and even the insertion of traits into wild populations.

How can we exploit the GxExM interaction to improve cotton productivity?

Tim Weaver, Kellie Gordon, Michael Bange

A definition of exploitation is the "action of making use of and benefiting from a resource". The aim of the research was to investigate if we can exploit the understanding in nutrition responses of cultivars with different management and environments to further improve yield. Over the past two cotton seasons (2017/18 and 2018/19) investigations into exploiting the GxExM interaction was undertaken using a recent released Bollgard® 3 cultivar (Sicot 746 B3F) and compared with an older non-Bollgard cultivar (Sicala V2) to better understand the nutrition responses of these cultivars with different management and environments (soils and climate). Sites were spread from the Macintyre, Gwydir and Namoi Valleys in the north down to the Riverina in the south. Cotton plants were sampled two weeks after first flower, and then every two weeks thereafter until maturity from each location. The plants were partitioned into thirds according to total nodes and each third separated into stem, leaf and seed for Total N analysis. A pattern of Total N redistribution between the "old" and "new" cultivars was able to be generated from first flower to maturity. Analysis of the data will seek to understand if there are particular nutritional responses of these cultivars to specific management and environmental drivers. If these can be identified the next step will be to develop strategies to seek to "exploit" these responses.

Does Cloudiness affect cotton damage by mirids in different parts of Australia?
Mary E.A. Whitehouse
With mirids, there appears to be a discrepancy between mirid numbers and the amount of damage sustained by a crop; which can lead to unnecessary insecticidal sprays. To avoid unnecessary sprays that can flare other pests, we need to explain the discrepancy. One explanation could be that interactions between environmental conditions, pest damage and plant compensation could increase or decrease the effect of mirid damage in different regions. Cloudiness, which reduces light to plants, may reduce a cotton plant's ability to compensate for damage by mirids, both in the short term and over the life of the crop. I tested if mirid damage or fruit removal on pre-flowering cotton under "cloudy" conditions (reduced light caused by white cages) might affect initial damage and final yield at Griffith and Narrabri. At Narrabri, heavy mirid pressure under "cloudy" conditions had no effect on initial damage (square numbers), but at the end of the season early square removal resulted in more bolls but not more lint. At Griffith, heavy mirid pressure under "cloudy" conditions initially reduced square numbers but did not affect the final number of bolls or the amount of ginned lint. These results demonstrate that early season mirid pressure on cloudy days had no effect on final yield at Narrabri and Griffith. At Griffith early season mirid pressure under "cloudy" conditions could in the short term reduce early squares, but the cotton compensated for this set-back by the end of the season. This study demonstrated that environmental and crop development parameters in different locations caused different short-term responses to mirid damage, but that cotton plants in the Namoi and Murrumbidgee river systems were able to compensate with no effect on yield.

PLENARY: The footprint of fashion: can cotton tread lightly in a circular economy?
Allan Williams
Despite its popularity as a fibre to wear, the cotton industry has been suffering bad publicity for at least the last 260 years - it has been associated with oppressive working conditions in the spinning mills that heralded the first industrial revolution, the use of slave and forced labour for both growing and processing, overuse of and pollution by agrochemicals, overuse of water and the introduction of biotechnology. And although its share of the world's fibre market is decreasing, cotton remains a popular fibre with consumers and total consumption continues to rise. An environmentally, economically and socially resilient industry that invests significantly in research and which has maintained its social licence to operate despite all the challenges thrown at it, and which will continue to do so. Perhaps. Hopefully. Or is it different this time? For the Australian industry, the myBMP Program played a key role in demonstrating its commitment to minimising the impact of its practices on the environment, both through investing in the necessary R&D, and implementing the findings. However when BMP was conceived, the term social licence to operate had not been coined in its modern conception, 28.8 kbits per second was high speed internet and experts were qualified - Twitter was over 10 years away. This paper will explore what's changed since myBMP was formulated to re-build social licence, and the role of research in reducing cotton's environmental footprint and informing consumer choices. A focus will be the changing attitudes to agriculture, and the implications for the cotton industry of the emphasis on reducing the environmental footprint of food and clothing - what does cotton need to do to compete with synthetic fibres in a more circular world?

Improving cotton defoliation: is 'time of the day' a factor for improved efficacy?
Sandra Williams and Michael Bange
Cotton defoliation is the application of harvest-aid chemicals to encourage cotton leaves to drop from the plant. Successful defoliation is part of growing a profitable cotton crop, as it allows the grower to harvest a clean crop and on time. Recommendations relating to harvest-aid use refer to the temperatures during the days following to allow best efficacy. Cooler temperatures following the application of defoliants slow down the diffusion rate of the harvest-aid and the formation of the abscission layer. A factor that has not been studied extensively is the 'time of day' or the temperature effect at the time of harvest-aid application. Extensive research in the use of herbicides shows that the temperature of the crop at the time of application plays a significant role in determining final efficacy. The studies here begin to investigate whether this effect is important for defoliation efficacy and if it is, recommendations will be developed. Field research studies were undertaken where 'time of day' effects on defoliation efficacy were assessed following treatment applications on three separate occasions during March, April and May 2019. On each occasion, two harvest-aid products (Dropp® and Escalate® UltraMax) were applied at 7am, 10am, 1pm and 4pm. The three dates and time of application were chosen to vary air and canopy temperature at the time of application. Defoliation efficacy was measured by assessing leaf drop 5 and 7/8-d post application. With the data combined and using a stepwise linear regression analyses there was significant positive relationships between canopy temperature and leaf drop on all occasions. There were also significant improvements in the regressions when the date of application was included (5 d - R^2 = 0.76; 7 d R^2 = 0.76). There were no differences in the harvest-aid products. Overall the results showed that considering the 'time of day' when applying harvest-aids can improve defoliation.

Cotton is moving north: Success is more than overcoming biophysical, supply chain and licence to operate challenges
Stephen Yeates and Paul Grundy
The current rapid expansion of commercial cotton into tropical Australia is unprecedented in a century long desire for a cotton industry. Driving this expansion is: freedom to grow cotton in WA and NT with GM moratoria and a cotton ban lifted respectively; new land and water opportunities in NW Qld; drought refuges from southern production areas; the need for regional development; R&D demonstrating promising yield and quality; varieties with Bollgard 3 technology expanding the planting window and reducing operational risk; opportunists hoping for capital gain land investments. Unfortunately, the saying "if you don't know history you are destined to repeat it" has a long history of being ignored in northern Australia resulting in too many failed copping industries; will the current white gold rush defy history? Described is how current R&D has confirmed the tropical north, particularly the wet season, requires locally developed management practices to reliably produce viable cotton crops. While the technical achievements of this work are undeniable the practice changes required are much more than a new "package" or cake mix to follow. Managing high yielding tropical cotton will require a high level of new human skills built from experience. Outside the Ord River where current R&D is developing these skills with the key land developer prior to gin scale production, rapid expansion is planned or occurring without sufficient seasons to develop the necessary experience. Unless the investors have deep pockets, the learning cost could be too high and the challenge of overcoming the enthusiasm of the unconsciously unskilled in the north may endure.

A BLOB-based Approach to UAS Collected Crop Data in Cotton
Andrew Young, James Mahan, William Dodge, Paxton Payton
The use of aerial imagery in agriculture is increasing. Improvements in unmanned aerial systems and the hardware and software used to analyse imagery are presenting new options for agricultural studies uses of these emerging tools. One of the challenges associated with improving crop performance under water deficit conditions is the increased variability in the growth and development inherent in low water settings. The chaotic nature of plant growth and development under water deficits makes it difficult to monitor the response to environmental changes. Small field and plot-level experiments are often variable enough that averages of seasonal crop characteristics are often of limited value to the researcher. This variability leads to a desire to be able to resolve fields on finer temporal and spatial scales. While UAS imagery provides an ability to monitor the crop on a useful temporal scale, the spatial scale is still difficult to resolve. In this study an automated computer software framework was developed to facilitate resolving field and plot crop imagery to finer spatial resolutions. The method uses a BLOB-based algorithm to automate the generation of AOMs as a tool for crop analysis. The use of the BLOB-based system is demonstrated in the analysis of plots of cotton grown in Lubbock, TX during the summer of 2018. The method allowed the creation and analysis of 1133 AOMs from the plots and the extraction of agronomic data that described plant growth and development.

Fulbright: Verticillium wilt in Cotton
Shelby Young, Karen Kirkby, Jonathan Plett
Shelby Young of Texas Tech University is conducting plant pathology research in Australia through a 2020 Fulbright Future Scholarship, funded by the Kinghorn Foundation. In affiliation with the New South Wales Department of Primary Industries and Western Sydney University, Young will pursue collaborative research on Verticillium wilt in cotton over a 10-month program. Initiatives include examining metabolic plant-pathogen responses during the disease cycle and the effects of variable nitrogen and irrigation rates on Verticillium wilt incidence in the field. In addition, Young has partnered with the Lower Namoi Cotton Growers Association to explore the relationship between Verticillium wilt inoculum detected in Australian cotton fields prior to planting and disease incidence later in the season.

Establishing a spectral library to predict soil physical and chemical properties in cotton growing soils

Dongxue Zhao, Maryem Arshad, Nan Li, Xueyu Zhao, John Triantafilis

Management of cotton growing soil in Australia, requires information about soil physical and chemical properties. However, standard laboratory analysis is tedious and therefore time-consuming and expensive. The use of visible and near-infrared (Vis-NIR) spectroscopy has been demonstrated as an adjunct; whereby, soil spectral libraries have been built to predict soil properties. While various models have been compared and soil physical and chemical properties investigated, few, if any studies, have assessed the development of a spectral library for the highly productive vertosols. In addition, the effect of depth on the model performance has also seldom been discussed. In this paper, our first aim is to determine which model (e.g. a machine learning algorithm (Cubist) or partial least squire regression with bootstrap aggregation (bagging-PLSR)) produces the best predictions of soil physical (e.g. clay, silt and sand content) and chemical (e.g. CEC, ESP and pH) and thereby develop a vis-NIR spectral library using spiking. Our second aim was to see if we can build individual spectral libraries using spiking to predict physical and chemical properties in seven cotton growing areas of Australia. The third aim was to compare the development of spectral libraries from individual depths, including; topsoil (0-0.3 m), subsurface (0.3-0.6 m), subsoil (0.9-1.2 m) and combined (0-1.2 m). We conclude that overall the bagging-PLSR was superior. Using a spiking approach, a vis-NIR spectral library could be established to satisfactorily predict clay (Lin's = 0.83) and CEC (0.81), with silt (0.73) and sand (0.71) also satisfactory. However, predicting ESP (0.54) and pH (0.62) was equivocal. To improve prediction for ESP and pH, a larger more varied set of data would be required. Moreover, a combined depth spectral library enabled a more consistent set of calibration and validation data.

DSM of clay in 3-dimensions using EM38 and EM34 data and inversion modelling in the cotton area

Xueyu Zhao, Jie Wang, Dongxue Zhao, Nan Li, Ehsan Zare and John Triantafilis

Issues of water use efficiency associated with storage reservoirs are problematic in some irrigated cotton areas, because leakage has led to point source salinization in some areas. Information about the areal distribution of clay is therefore necessary to understand where existing water storages may be better relocated. We show how electromagnetic (EM) induction data from a reconnaissance survey of EM38 and EM34 instruments can be used with EM inversion (EM4Soil). This is because the collected apparent electrical conductivity (EC_a – mS/m) can be inverted to estimate true electrical conductivity (σ – mS/m) and correlated with clay. The first aim was to develop a quasi-two-dimensional (Q-2D) model, to develop a linear regression (LR) between σ and clay collected from 10 soil sample locations to a depth of 12 m, along a single transect. This was achieved with an LR equation of the form $clay = 22.12 + 0.2\sigma$ with a good correlation coefficient ($R^2 = 0.74$). The second aim was to use the LR to predict clay using a Q-3D model developed from EM38 and EM34 EC_a collected on an approximate 0.5-1 km grid across 50,000 ha. A validation set of clay, collected from 34 soil sample location, indicated a good concordance was achieved (Lin's = 0.80). We conclude the approach provides useful information on a reconnaissance scale and indicates where more detailed information may be collected to confirm problematic areas. In addition, locations can be identified where more suitable locations can be investigated. To better resolve the areal short scale variation and where the present and prior streams are juxtaposed against the clay alluvial plain, more EC_a data should be collected. To improve resolving the depth of clay and underlying migrational channels, EC_a from a DUALEM-421 instrument could also be collected and used in inversion modelling.

New strategies to generate cotton germplasm resistant to verticillium wilt
Qian-Hao Zhu, Iain Wilson, Danny Llewellyn and Warwick Stiller
Verticillium wilt (VW) is the most important disease threatening cotton production in all cotton-producing countries, including Australia. It is a soil-transmitted vascular bundle disease caused by the fungal pathogen *Verticillium dahliae* that may survive for decades in soil and cannot be eliminated effectively by fungicides. Breeding *V. dahliae*-resistant cotton varieties is the most effective means to reduce the impact of the disease on cotton production, however, one of the major challenges is the lack of resistance in the *Gossypium hirsutum* germplasm pool to *V. dahliae*. Although higher levels of resistance do exist in *G. barbadense* and *G. arboreum*, introgression of the VW resistance from these species into elite commercial *G. hirsutum* varieties is time-consuming and may have significant yield penalties due to linkage drag. To overcome these shortcomings, we are exploring new strategies for developing VW-resistant germplasm. Nucleotide-binding leucine-rich repeat (NLR)-encoding genes are vital to disease resistance in plants. Many NLR genes are negatively regulated by miR482, a 22-nt non-coding small RNA. Our rationale was to test whether it is possible to enhance cotton's VW resistance by down-regulating the expression level of miR482 to up-regulate expression of their target disease resistance genes. We generated multiple transgenic cottons with a reduced level of miR482 and found that these transgenic cottons indeed showed an enhanced resistance to VW. The resistance persisted in all generations (up to T4) assayed. The cotton genome contains hundreds of NLR genes and ~12% of them are predicted to be regulated by miR482. In addition to VW, some of the NLR genes targeted by miR482 may also be related to resistance to other cotton diseases, such as fusarium wilt and bacterial blight, so the transgenic cottons may provide a broad resistance to these other diseases. We are currently verifying this hypothesis using disease assays with these two pathogens.