Australian cotton science continuing to lead...

2023 Australian Cotton Research Conference

CONFERENCE PROCEEDINGS

TOOWOOMBA

5-7 SEPTEMBER 2023

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2023 Australian Cotton Research Conference

Foreword

Welcome to the 5th biennial Australian Cotton Research Conference held from Tuesday 5th to Thursday 7th September 2023 in the Armitage Centre at the Empire Theatre in the CBD of Toowoomba. This conference is only possible thanks to the very generous support of sponsors, particularly our major sponsors, Cotton Research and Development Corporation (CRDC) and Cotton Seed Distributors (CSD), in conjunction with our other sponsors CSIRO, Bayer, and University of Southern Queensland (UniSQ). And most importantly, "Welcome back" after the hiatus of the biennial series due to Covid-19 travel restrictions in 2021.

The theme of the conference is 'Australian Cotton Science – Continuing to Lead'. Since its inception over a decade ago the focus of this conference has been about the development of scientific skill, novel inquiry, and research skill in our cotton industry. This is important for our industry as it continues to evolve, so please actively engage our presenters with your questions throughout the conference to enhance that science development.

The Australian cotton industry has so much to be proud of, and continues to lead on the international stage. Thanks to science research, Australia is one of the most water efficient cotton producers, amongst producers of the highest quality fibre worldwide, and has the most technologically advanced varieties.

The 2023 Australian Cotton Research Conference features speakers from across Australia and international research institutions, addressing topics ranging from our ever-evolving cotton pest and disease threats, the physical chemical and biological aspects of our soils, the nature and control of weeds, through to novel genetics, artificial intelligence, data management, social sciences, and crop physiology in different climates.

This conference has a strong focus on enhancing linkages to support newcomers and early career researchers entering the Cotton Industry, with the Cotton 101 lunch, and a science communication panel with ABC Landline's Pip Courtney and experts from CRDC, CSIRO, and UniSQ.

This conference was only possible thanks to the organising committee, and the input of the Management Committee of the Association of Australian Cotton Scientists (AACS). Many thanks to you all. In particular, the experience, commitment and tireless effort of AACS outgoing President Dr Paul Grundy, and Tonia Grundy have been invaluable in fully developing this conference.

Dr Alison McCarthy and Associate Professor Joseph Foley (UniSQ)

Co-chairs of the 2023 Australian Cotton Research Conference

2023 Conference Committee

Alison McCarthy, UniSQ	Megan Woodward, CottonInfo	Linda Smith, DAF
Joseph Foley, UniSQ	Nicole McDonald, CQU	Susan Maas, CRDC
Paul Grundy, DAF	Li Zitong, CSIRO	Kristen Knight, Bayer
Warren Conaty, CSIRO	Guna Nachimuthu, NSW DPI	Lucy Egan, CSIRO

Summary program

Tuesday 5 September	Wednesday 6 September	Thursday 7 September
7:30 Registration desk open 8:00 Tea & coffee	7:45 Tea & coffee (Registration desk open)	7:45 Tea & coffee (Registration desk open)
8:30 Housekeeping 8:40 AACS Welcome	8:25 Housekeeping	8:25 Housekeeping 8:30 **AACS AGM**
Session 1: Plenary Chair: Paul Grundy 9:00 Oliver Knox 9:30 Merry Conaty	**Session 5: PLANT** Chair: Joseph Foley 8:30 Plenary (Warwick Stiller) 9:00 Speaker sessions	**Session 9: PLANT** Chair: Guna Nachimuthu 9:15 Speaker sessions
10:00-10:30 Morning tea	10:00-10:30 Morning tea	10:15-10:45 Morning tea
Session 2: PEOPLE Chair: Susan Maas 10:30 Speaker sessions 12:10 Plenary (Simon Blyth)	**Session 6: TECH** Chair: Warren Conaty 10:30 Plenary (Alison McCarthy) 11:00 Speaker sessions	**Session 10: PADDOCK** Chair: Alison McCarthy 10:45 Plenary (Graham Charles) 11:15 Speaker sessions
12:30-1:30 Lunch	12:35-1:30 Lunch	12:25-1:30 Lunch
SESSION 3: Concurrent 1:30 Session 3a: PADDOCK Chair: Linda Smith 1:30 Session 3b: PLANET/PLANT (Church Theatre) Chair: Kristen Knight	**Session 7: NEXT GEN** Chair: Nicole McDonald 1:30 Plenary (Katie Broughton and Yui Osani) 2:00 Speaker sessions	**Session 11: PADDOCK** Chair: Lucy Egan 1:30 Speaker sessions 3:05 Closing statements
3:20-3:45 Afternoon tea	3:20-3:45 Afternoon tea	3:30-4:30 Afternoon tea
Session 4: PLANT Chair: Zitong Li 3:45 Speaker sessions	**Session 8: COMMS** Chair: Megan Woodward 3:45-4:30 Discussion panel	
5:00-6:30 Welcome drinks (Empire Theatre Complex)	6:00-10:30 Conference Dinner (UniSQ Refectory)	

Note: All conference sessions are in the Armitage Centre, except for Session 3b which is in the Church Theatre. The conference dinner is at the Refectory (R block) at the University of Southern Queensland (Toowoomba campus).

Tuesday 5 September

7:30	Registration desk open
8:00	Tea & coffee
8:30	Housekeeping
8:40	AACS Welcome
9:00-10:00	**Session 1: Plenary sessions**
CHAIR	**Dr Paul Grundy**
9:00	**Oliver Knox:** Soils – their health, myths and sustainable future
9:30	**Merry Conaty:** A digital strategy for the Australian cotton industry, what is it and why should researchers be excited?
10:00-10:30	Morning tea
10:30-12:30	**Session 2: PEOPLE**
CHAIR	**Susan Maas**
10:30	**Don Jones:** A private/public sector collaboration to address FOV
10:45	**Kieran O'Keeffe:** Southern NSW Grower groups — the key to adoption of best practice.
10:50	**Nicole McDonald:** Utilising Research to Address the National Agricultural Workforce Strategy for the Australian Cotton Industry
11:05	**Nikki Kelly:** Exploring a cotton and grains agricultural apprenticeship model
11:15	**Melissa Sullivan:** How to attract and retain young people to the cotton industry
11:25	**Derek Long:** Putting cotton in the spotlight in agricultural education
11:40	**Melinda Mylek:** Are we sustaining wellbeing in the cotton industry and cotton communities?
11:55	**Renée Anderson:** Building sustainable practices - The connection between wellbeing and agriculture
12:10	**Simon Blyth** (plenary): The role of technology in supporting adoption of best practice - Maverick case study
12:30-1:30	Lunch
1:30-3:20	**Session 3: Concurrent sessions**
	Session 3a: PADDOCK
	CHAIR: Dr Linda Smith
1:30	**Sally Taylor:** Insect pest management and research in U.S. cotton
1:45	**Jamie Hopkinson:** Resistance to spirotetramat in silverleaf whitefly. What's happening in cotton?
2:00	**Amanda Padovan:** The challenges and opportunities of molecular resistance monitoring: A case study in *Helicoverpa armigera* Bt resistance
2:15	**Dinesh Kafle:** Plant-parasitic nematodes, a threat to Australian cotton?
2:30	**Greg Holt:** Orienting and rotating round modules to reduce plastic contamination risk
2:45	**René van der Sluijs:** Effect of nitrogen application rates on cotton yield and fibre quality - results from recent trials in Australia
3:00	**Joseph Foley:** Demonstrating and integrating irrigation technology for cotton
3:05	**Wendy Quayle:** Characterising nitrogen-water interactions in cotton bankless channel surface irrigation systems
	Session 3b: PLANET/PLANT (Church Theatre)
	CHAIR: Dr Kristen Knight
1:30	**Michael Rose:** Diagnosing agrochemical "drift" injury through leaf tissue analysis — what have we learnt?
1:45	**Malem McLeod:** The trends of water productivity and water sustainability indicators for Australian cotton from the benchmarking program
2:00	**Murray Hall**: Innovative fibres, their economic viability, sustainability, threats, and opportunities - with specific reference to cotton
2:15	**Simone Heimoana:** Closing the loop – developing circular pathways for cotton production systems by creating value options from cotton gin trash waste
2:30	**Blake Palmer:** Does foliar nutrition help cotton crops overcome waterlogging?
2:45	**Paul Grundy:** Why early season square retention rarely matters for high yielding Bollgard 3 In Australia
3:00	**Larissa Holland:** Improving understanding of growth and development of cotton varieties
3:15	**Xiaoqing Li:** Gene editing in cotton, what is it good for?
3:20-3:45	Afternoon tea

3:45-5:00	**Session 4: PLANT**
CHAIR	**Dr Zitong Li**
3:45	**Melanie Soliveres:** A study of cotton bunchy top, will it go viral?
3:50	**Lucy Egan:** Untangling the Gordian knot of breeding for resistance to Verticillium wilt
4:05	**Iain Wilson:** Molecular biology to the rescue (again!): How genomics aids managing disease resistance in cotton
4:10	**Hannah Hartnett:** Influence of seed characteristics and physiological quality on establishment vigour
4:25	**Qian-Hao Zhu:** Pollen based cotton transformation, is it possible?
4:40	**Philippe Moncuquet:** The cotton genome puzzle: The value of connecting the pieces
5:00-6:30	Welcome drinks

Wednesday 6 September

7:45	Tea & coffee (Registration desk open)
8:25	Housekeeping
8:30-10:00	**Session 5: PLANT**
CHAIR	**Dr Joseph Foley**
8:30	**Warwick Stiller** (plenary): From the Holocene epoch to the era of AI
9:00	**Peng Chee:** QTL validation and identification of candidate genes in qFL-Chr.25, a *G. barbadense*-sourced QTL conditioning for increased fiber lengths in four diverse *G. hirsutum* backgrounds
9:15	**Pierce Rafter:** Exploiting GxE interactions to advance rainfed cotton yield
9:30	**Annelie Marquardt:** New approaches to improving water productivity in cotton
9:45	**Demi Sargent:** Unravelling the components of mesophyll conductance in *Gossypium* species to improve tolerance to heat and drought stress
10:00-10:30	Morning tea
10:30-12:30	**Session 6: TECH**
CHAIR	**Dr Warren Conaty**
10:30	**Alison McCarthy** (plenary): Artificial intelligence: what is it and what does it mean for cotton?
11:00	**Greg Holt:** AI classifier to enable an auto-calibration system for a gin-stand based machine-vision inspection system for plastic contamination
11:15	**Moshiur Farazi:** What can you see? Harnessing deep learning for cotton leaf hairiness phenotyping with HairNet2
11:30	**Xuesong Li:** New ways to measure old traits: a case study in cotton biomass dynamics
11:45	**Manish Patel:** Better than 20/20 vision: the role of AI in disease phenotyping
12:00	**Zitong Li:** Can A.I. select cotton lines suited for different environments?
12:15	**Chris Teague:** Predicting micronaire using variables from an industry agronomic database (ERICA)
12:25	**Craig McDonald**: Extensive Validation of the BARRY Model for the 2021 -22 Season
12:35-1:30	Lunch
1:30-3:20	**Session 7: NEXT GEN**
CHAIR	**Dr Nicole McDonald**
1:30	**Katie Broughton** and **Yui Osani** (2019 Early Career Award recipients)
2:00	**Chantal Corish:** Understanding the role psychological safety can play in enhancing the learning and performance behaviours of leaders and employees on Australian cotton farms
2:05	**Grace Fang:** Over-expression of P450 CYP6CM1 associated with resistance to imidacloprid in Australian *Bemisia tabaci* MEAM1
2:20	**Garima Dubey:** Drought resilient cotton: Developing a new biochemical understanding of developing drought resistant cotton.
2:25	**Sharna Holman:** Understanding *Spodoptera litura* larval survival in Bollgard 3 crops in Northern Australia
2:40	**Harry Paine:** Benefits of a sprayable mulch in dryland cotton systems
2:45	**Jonathon Moore:** Palaeochannel spaghetti: Within-field soil and cotton yield variability on southern NSW palaeochannel systems
3:00	**Mikaela Tilse:** An approach to map cotton fibre quality on commercial farms using remote sensing and geostatistics
3:05	**Arun Chandra Manivannan:** Sustainable saccharification: Gin waste to fermentable sugars by microbial enzymes
3:20-3:45	Afternoon tea
3:45-4:30	**Session 8: COMMS discussion panel**
	Meg Woodward: Communicating good science: panel discussion
6:00-10:30	Drinks at 6:00 for Conference Dinner seating at 6:30. Dinner includes AACS award and life member announcements.

Thursday 7 September

7:45	Tea & coffee (Registration desk open)
8:25	Housekeeping
8:30	**AACS AGM**
9:15-10:15	**Session 9: PLANT**
CHAIR	**Dr Guna Nachimuthu**
9:15	**Jon Baird:** Assimilated N – the importance of internal nitrogen to developing fruit in cotton plants
9:30	**Robert Sharwood:** Opportunities for improving cotton production under future climates – the new role of synthetic biology.
9:45	**Michael Bange:** Boll periods in modern cotton systems
10:00	**Katie Broughton:** Can we alter crop development using novel plant growth regulators?
10:15-10:45	Morning tea
10:45-12:25	**Session 10: PADDOCK**
CHAIR	**Dr Alison McCarthy**
10:45	**Graham Charles** (plenary): The weed control fix
11:15	**Jeff Werth:** Utilising the double knock to increase efficacy of weed control on major weeds in Xtendflex cotton systems
11:20	**Tim Weaver:** Future Farm: Using a shiny App and Google Earth to access Satellite data to make better N decisions.
11:35	**Guna Nachimuthu:** Legacy effects of soil compaction on cotton and wheat crops in Vertosols: Insights from a field experiment
11:40	**Gupta Vadakattu:** Starving soil microbes: consequences to cotton plant and soil health
11:55	**Patrick Filippi:** Mapping cotton fields, predicting yield, and identifying yield limitations using scalable approaches for the Australian cotton industry
12:10	**Eric Koetz:** A baseline assessment and survey of weeds and weed management systems in northern cotton regions
12:25-1:30	Lunch
1:30-3:05	**Session 11: PADDOCK**
CHAIR	**Dr Lucy Egan**
1:30	**Kaitlyn Bissonnette:** Challenges facing U.S. cotton production: a focus on pathogens and nematodes
2:00	**Murray Sharman:** Development and application of rapid molecular assays for cotton pathology
2:05	**Emma Chorley:** Cotton Disease Action Research Initiative – What have we achieved and learnt in the first year?
2:20	**Donald Gardiner:** Fluorescently tagged *Verticillium dahliae* to understand the infection process on cotton and other plants
2:25	**Karthikeyan Muthusamy/ Sambasivam Periyannan:** How are diseases in cotton managed in India, the leading producer?
2:40	**Linda Scheikowski:** An overview of Verticillium host range
2:45	**Duy Le:** *Alternaria alternata* causes distinct foliar symptoms on cotton in New South Wales
3:00	**Linda Smith:** Reoccurring wilt: The Eutypella story
3:05	Closing statements
3:30-4:30	Afternoon tea

Plenary speakers

Artificial intelligence: what is it and what does it mean for cotton?

Dr Alison McCarthy, UniSQ

Artificial intelligence has rapidly evolved into use in everyday tools and is enabling smarter decision-making and analytics across all industries including agriculture. This presentation will give an overview of how artificial intelligence works, and considerations, examples and opportunities for use in agriculture and particularly cotton, for example for sensing and machine vision.

A digital strategy for the Australian cotton industry, what is it and why should researchers be excited?

Dr Merry Conaty, CRDC

Across agriculture and all our supply chains, the demand for data is growing. As markets and brand partners demand more granular information about products and how they have been produced, the Australian cotton industry faces a future where data collection, aggregation and provision to various parts of the supply chain is becoming an urgent priority. Put simply, without high quality data we won't have a market to sell the cotton we produce, and without a market, we won't have an industry. CRDC, Cotton Australia, ACSA, ginners, growers, researchers and industry companies like CSD have come together over the last 2 years to develop a 'Digital Strategy for the Australian Cotton Industry'. Included in this is issues of data collection and management, data privacy and access, as well as a large scale proposal to aggregate on farm and supply chain data into one place, which would make us the first Ag industry in Australia to successfully aggregate all our data onto one central platform. Merry Conaty will describe this new industry data platform, and how it can support and enable us as an industry to describe who we are as an industry, how we produce our cotton, and ensure long term market access for Australian cotton, while simultaneously enhancing the research we do and measuring its impact.

From the Holocene epoch to the era of AI

Dr Warwick Stiller, CSIRO

Cotton has been grown, spun and woven into cloth for at least 5,000 years and by 1500 was generally known around the world. In this presentation, Warwick Stiller takes you on a journey to unravel the origin of cotton, drawing insights into its biology, potential, and limitations. We delve into the historical tapestry of cotton cultivation and its adaptation to diverse environments, shedding light on the crop's unique characteristics. By understanding its origins, we gain valuable perspectives on cotton's inherent traits and laying the foundation for unlocking its untapped potential. For hundreds of years, breeders have aimed to improve the crop and are recognised as the grand integrators who constantly balance the imperative for strategic research with the demands of commercial profitability and timelines. We explore the pivotal role breeders have played in shaping past, present, and future innovation. Ground-breaking technologies like artificial intelligence (AI) and gene editing have the potential to further revolutionise the field, opening new avenues for progress with data-driven insights that promise further optimization of breeding strategies and accelerated variety development. Applying these advancements in a practical context, we present a captivating case study that explores new frontiers in cotton breeding. While we celebrate the triumphs of cotton breeding, we also confront the sobering realities of intricate genome complexities and the challenges this provides when exposed to a high input managed farming system.

Soils – their health, myths and sustainable future

Oliver Knox, UNE

Soil health is something that most of us have heard of, but what does it actually mean? Against a background of an increasing body of literature on the subject and a national soil strategy promise of indicators to measure it, we proposed a sustainable soils framework in 2022 that has the potential to go beyond our cotton fields. The driver for this was an acceptance of what we know of our Australian soils, placing scientific evidence over beliefs and, most importantly, to provide something that our growers could easily embrace. With 2023 being the year where the FAO is reminding us that soil is where food begins, why not come on a journey of exploration, discovery and realisation with Oliver Knox, which might just help you better appreciate the dirt beneath your feet for the fragile and phenomenal ecosystem that your soils are. Who knows, you might get so excited that you may end up soiling your undies.

The weed control fix

Graham Charles, NSW DPI

Weeds have been the bane of the cotton industry since its inception (the first commercial crop at Wee Waa in 1961-2 was severely impacted by weeds and flooding). Graham Charles highlights that even though a range of residual and a few over-the-top herbicides are now available, weeds are still adversely impacting yields and require both time and money to manage. Back in 1989, weed control cost around $187/ha, quite a lot relative to the lower yields and prices of that time. The cost of weed management to cotton growers is much lower today…

…or is it? We must not forget the hidden costs of weed control: particularly the scourge of herbicides used in other crops or fallows, that then drift on to a cotton crop, an all-too-common but devastating experience for some. And then there are the 'own-goals': root pruning from over-aggressive inter-row cultivation or side dressing; the damage from residual herbicides applied in preceding crops and fallows; residues from tanks that weren't cleaned out sufficiently, or when the wrong drum was used accidentally. What about the compaction caused by spraying or cultivation operations, or the damage to the neighbouring field, river or the wider environment from the herbicides, the dust, or soil run-off. Consider also future damage from diseases and insects harbouring on uncontrolled weeds, and greenhouse gasses generated by weed management activities.

So the true cost of controlling weeds is usually much higher than we think, but is there a solution?

The role of technology in supporting adoption of best practice - Maverick case study

Simon Blyth, LX Group and INCYT

INCYT/LX partnered with CRDC through the BRII grant program to develop Maverick, a machinery agnostic technology solution to help growers reduce spray drift and maximise application efficacy. Spray operators run a highly complex multivariable gauntlet within a set of fixed and moving constraints which all too often leads to devastating spray drift events. Reductionistic approaches to the problem such as "rules of thumb" have proven to be ill equipped to effectively solve this problem. Maverick is an intuitive, user-friendly software application that combines that latest INCYT Smart Farm Technology (including real-time dashboards, sensors on-farm & on-machine and external data sources) to deliver a software based expert advisory system that navigates much of this complexity for the user. Maverick assists the operator to optimise spray planning & machinery set-up, spray application (with live cabin view) and post-spray efficacy evaluation, ultimately motivating and equipping the operator to achieve best practice in the field.

Special sessions

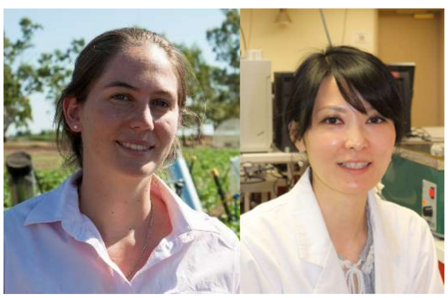
Communicating good science: panel discussion

Megan Woodward (CottonInfo), Pip Courtney (ABC), Iain Wilson and Colleen MacMillan (CSIRO), Sarah Green (UniSQ)

Whether you've just started your research career or you've had thousands of journal articles published – there's diamonds ready to be mined in this panel discussion. Join CottonInfo Communications Lead Megan Woodward as she facilitates a discussion with some of the best science communicators in the business as well as those who know exactly what makes a good yarn – including ABC Landline's Pip Courtney.

2019 Early Career Award recipients

Katie Broughton (CSIRO) and Yui Osani (University of Queensland)



One of Katie's favourite school texts was The Road Not Taken by Robert Frost. She found the imagery to be incredibly beautiful, but she felt the internal debate inside that one traveller standing where those two roads diverged. Then, at the end of school, Katie stood at her own personal crossroad with two university offers in hand- a Bachelor of Medical Science and Biotechnology OR a Bachelor of Agricultural Science. Meanwhile, Yui stood at an open field - she could have taken any degree if she was willing to wait. She took the most convenient path (Bachelor of Arts) at that time, only to change her mind soon after. From only really knowing that they thoroughly enjoyed biology at school, to receiving the Association of Australian Cotton Scientist Early Career Scientist Award in 2019, they never anticipated this would be the path they would take.

Abstracts

Building sustainable practices- The connection between wellbeing and agriculture.

Renée Anderson
Queensland Farmers' Federation

The well-being of farmers and agricultural industries is crucial for promoting the adoption of best practices. Prioritising well-being leads to a thriving community that is more open to sustainable practices, benefiting farmers, the environment, and society. Sustainability involves human, social, environmental, and economic aspects, with worker health gaining significance, especially during the pandemic.

In the cotton industry, stressors can affect decision-making, highlighting the importance of considering social and human factors alongside environmental and economic ones in sustainable programs. Effective communication and supportive environments are vital for encouraging the adoption of best practices, with social framing and leadership influencing farmer behaviour. Strengthening relationships and community support also enhance decision-making processes.

In summary, achieving sustainable practices in agriculture requires a people-centric approach, focusing on the well-being of individuals and communities.

Assimilated N – The importance of internal nitrogen to developing fruit in cotton plants.

Jon Baird
NSW DPI

Nitrogen has several roles within cotton plants – from building nuclei to developing enzymes to initiate and develop new growth. The major plant functions rely on proteins, of which nitrogen is a major component through the development of amino acids. Nitrogen use by cotton plants is low early in the seasons, with uptake exponentially increasing during flowering through to maturity as nitrogen is required to mature the important seed and fibre. Simultaneously during this stage, inorganic N is sourced from the soil plateaus mid-season, meaning the most reliable nitrogen source for the ever-important seed and lint fibre development is most likely from remobilised internal nitrogen. A glasshouse experiment was initiated to investigate the internal nitrogen assimilation in terms of quantity and transfer rate and the potential to utilise more efficient plant pathways for further nitrogen efficiency. The experiment utilised stable isotope 15N to illustrate the final fate of nitrogen and quantify nitrogen transfer rates within the plant. Fertiliser recovery ranged between 30% and 65%, depending on fertiliser application timing. Applying fertiliser pre-plant led to greater dry matter production early in the plant growth, maintaining higher dry matter and fertiliser recovery rates through to the early fruiting stage (57 days after sowing) compared to treatments where fertiliser was applied at the early square.

Boll periods in modern cotton systems.

Michael Bange, Nicolas Finger, Jane Caton, Kavina Dayal, and Chris Teague.
Cotton Seed Distributors

Important knowledge used in cotton management is to understand the period from when the last fruit has flowered (defined as the last effective flower (LEF) or 'cutout') to when it is mature ready for harvest (last effective boll). The timing of cutout has important implications for both yield and quality. In estimating cutout date across regions historical climate data is used to calculate the timing of the LEF from a response of boll period to temperature and this is used to back-calculate this period in time from a pre-determined end of season harvest date. The current boll period temperature response used within the industry was developed from cultivars used in the 1980's and there are concerns that it may no longer be relevant today. Using boll period collected in recent years the current industry response was evaluated and showed that it was reasonable ($r2 = 0.64$) in its ability to predict boll period. A new function generated from the data improved predictability especially when the nodal position was included ($r2 = 0.73$). However, all functions had a slight and similar bias towards underestimating the boll period at higher nodal positions which are more relevant to the period of LEF. An estimate of boll period using the 15/32 day degree approach was also developed. Results suggest opportunities to implement a function that can be more accurate and thus improve the estimates of LEF.

Challenges facing U.S. cotton production: a focus on pathogens and nematodes.

Dr. **Kaitlyn M. Bissonnette**
Cotton Incorporated

Cotton production in the U.S. spans from the eastern to the western seaboard representing multiple climates, each favoring different pathogens and nematodes. As environmental conditions have begun to change in U.S. cotton production regions, so too have the pathogen and nematode threats. These include not only re-emerging and endemic threats, but also newly emerging and invasive threats. This talk will focus on Cotton Incorporated's priorities in pathology and nematology for the U.S. cotton production system. To prioritize threats in the U.S., the cotton producing states are divided into production regions, eastern and western, based on environmental conditions and dominant pathogen and nematode threats. Emphasis will be placed on research advances and Cotton Incorporated's engagement with researchers to address threats relevant to the global cotton community.

The role of technology in supporting adoption of best practice- Maverick case study.

Simon Blyth (*Plenary*)
LX Group

INCYT/LX partnered with CRDC through the BRII grant program to develop Maverick, a machinery agnostic technology solution to help growers reduce spray drift and maximise application efficacy. Spray operators run a highly complex multivariable gauntlet within a set of fixed and moving constraints which all too often leads to devastating spray drift events. Reductionistic approaches to the problem such as "rules of thumb" have proven to be ill equipped to effectively solve this problem. Maverick is an intuitive, user-friendly software application that combines that latest INCYT Smart Farm Technology (including real-time dashboards, sensors on-farm & on-machine and external data sources) to deliver a software based expert advisory system that navigates much of this complexity for the user. Maverick assists the operator to optimise spray planning & machinery set-up, spray application (with live cabin view) and post-spray efficacy evaluation, ultimately motivating and equipping the operator to achieve best practice in the field.

Can we alter crop development using novel plant growth regulators?

Katie Broughton, Jane Caton, Bernadette Melton, Sandra Williams
CSIRO

A challenge for the Australian cotton industry is to maintain high lint quality and productivity under conditions of high climatic variability and unreliable water supply, particularly for dryland and water limited production systems. Altering crop development and canopy architecture through the application of different plant growth regulators may enable cotton growers to strategically manage their crops and facilitate a cotton system more resilient to abiotic stress. There are a number of novel plant growth regulators that could be useful in managing cotton production systems for stress but they are currently not utilised as information on when and how to apply them efficiently is lacking. For the past two seasons, we have conducted field experiments to investigate if and how novel plant growth regulators can be used to delay development of cotton. Our studies showed that the application of gibberellin inhibitors at specific development stages delayed time to first square, time to first flower and maturity. These results provided a better insight into the growth and development responses of cotton to exogenous application of plant growth hormones and may open up opportunities for improved crop management of Australian Cotton.

Sustainable saccharification: gin waste to fermentable sugars by microbial enzymes.

Arun Chandra Manivannan, Logeshwaran Panneerselvan, Thavamani Palanisami
Environmental and Plastic Innovation Cluster (EPIC), Global Innovative Centre for Advanced Nanomaterials (GICAN), Faculty of Engineering and Built Environment, The University of Newcastle

Australia Saccharification of waste biomass represents a promising and efficient solution for sustainable bio-energy production. This study investigates the potential for achieving robust degradation of gin waste without the need for pretreatment, thereby enhancing production sustainability. We successfully implemented a one-step saccharification process using a crude enzymatic extract derived from enriched thermophilic consortia to treat raw gin waste. The enrichment culture was obtained by incubating compost samples in Cellulose minimal media at 58 °C for one week, extracted cell-free supernatant and saccharified untreated gin waste. Notably, the production rates of sugars reached 0.8 mg/ml/hour at room temperature and an impressive 2.1 mg/ml/hour at 50-60°C, surpassing the efficiency of the reference material - filterpaper. However, it is important to note that cotton textile waste, including waste cotton fabrics, exhibited resistance to saccharification under both temperature conditions, limiting the universal applicability of this approach. Additionally, the thermophilic consortia demonstrated the ability to accelerate gin waste deconstruction in synthetic media, suggesting potential for semi-simultaneous ethanol production. This study provides valuable insights into the efficiency of isolated consortia for the valorization of cotton gin waste without pretreatment, achieving a comparable production rate, thereby holding promise for potential biofuel production.

The weed control fix.

Graham Charles (*Plenary*)
NSW Department of Primary Industries

Weeds have been the bane of the cotton industry since its inception (the first commercial crop at Wee Waa in 1961-2 was severely impacted by weeds and flooding). Graham Charles (NSW DPI) highlights that even though a range of residual and a few over-the-top herbicides are now available, weeds are still adversely impacting yields and require both time and money to manage. Back in 1989, weed control cost around $187/ha, quite a lot relative to the lower yields and prices of that time. The cost of weed management to cotton growers is much lower today…

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So the true cost of controlling weeds is usually much higher than we think, but is there a solution?

QTL validation and identification of candidate genes in qFL-Chr.25, a *G. barbadense*-sourced QTL conditioning for increased fiber lengths in four diverse *G. hirsutum* backgrounds.

Samantha Jo Wan[1], Sameer Khanal[1], Nino Brown[1], Pawan Kumar[2], Dalton West[1], Neha Kothari[3], Donald Jones[3], Lori Hinze[4], Josh Udall[4], Chris Saski[5], Andrew Paterson[6], Chris Delhom[7] and **Peng Chee***[1]
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An obsolete Upland line with introgressions from *G. barbadense*, Sealand 883, was previously shown to carry a quantitative trait locus (QTL) for fiber length (qFL-Chr.25). This QTL was transferred into four diverse genetic backgrounds (Acala SJ-4, Deltapine 50, GA 2004089, and Paymaster HS-26) that represented four major cotton-growing regions of the United States Cotton Belt. To more precisely determine the effect of the QTL, it necessitated the development of near-isogenic lines (NILs). A three year, multilocational study was conducted to test the deployment of qFL-Chr.25 into the four different backgrounds. The fiber analysis results showed a significant positive effect with the introgression of the qFL-Chr.25 locus on the length of fibers in all four backgrounds. In tandem with the field evaluation study, a transcriptome profiling study via RNA sequencing (RNASeq analysis) was conducted to identify putative candidate genes for the causal fiber length gene. The RNASeq analysis revealed three potential candidate genes that showed significant down-regulation during early fiber elongation stages in lines carrying the G. barbadense alleles. The three candidate genes in the qFL-Chr.25 region provide targets for functional validation using reverse genetics approaches.

Cotton Disease Action Research Initiative – What have we achieved and learnt in the first year?

Amanda Thomas[1], **Emma Chorley**[1], Rob Long[2]
[1]Cotton Seed Distributors Ltd Extension, [2]Crown Analytical Services

A need was identified for further disease research into management practices that occur on farm. Many growers and consultants are proactively trying different techniques for managing disease, and there was an opportunity to support this by applying a participatory action research approach across the industry.

This approach places the power to undertake the research with those who are most impacted. It encourages involvement in the design and direction of research; and allows challenges and opportunities to be examined in the context of a farming system.

The initiative is supported by CSD, CRDC and Crown Analytical through the Richard Williams Initiative and focuses on Black Root Rot and Verticillium Wilt. A key element was to be able to monitor disease inoculum in a field across multiple seasons using DNA testing to develop heat maps describing the level and distribution of the disease (offered by Crown Analytical).

In 12 months, the initiative has engaged 60 growers from across 7 regions. To date, 82 fields have been sampled with crop rotations such as cotton, forage, wheat, millet, corn, cover crop, canola and sunflowers. Early results support the impact that cotton on cotton rotations have in raising disease levels substantially. Ongoing monitoring of alternate crop rotations will help to understand their impact on disease levels and overall systems performance e.g. yield.

In future, it will be important to link with other disease research efforts throughout the industry.

A digital strategy for the Australian cotton industry, what is it and why should researchers be excited?

Merry Conaty (*Plenary*)
CRDC

Across agriculture and all our supply chains, the demand for data is growing. As markets and brand partners demand more granular information about products and how they have been produced, the Australian cotton industry faces a future where data collection, aggregation and provision to various parts of the supply chain is becoming an urgent priority. Put simply, without high quality data we won't have a market to sell the cotton we produce, and without a market, we won't have an industry. CRDC, Cotton Australia, ACSA, ginners, growers, researchers and industry companies like CSD have come together over the last 2 years to develop a 'Digital Strategy for the Australian Cotton Industry'. Included in this is issues of data collection and management, data privacy and access, as well as a large scale proposal to aggregate on farm and supply chain data into one place, which would make us the first Ag industry in Australia to successfully aggregate all our data onto one central platform. This presentation will describe this new industry data platform, and how it can support and enable us as an industry to describe who we are as an industry, how we produce our cotton, and ensure long term market access for Australian cotton, while simultaneously enhancing the research we do and measuring its impact.

Understanding the Role Psychological Safety Can Play in Enhancing the Learning and Performance Behaviours of Leaders and Employees on Australian Cotton Farms.

Chantal Corish
Central Queensland University

Psychological safety is strongly associated with improved team effectiveness and organisational performance through the mediating roles of team learning behaviour and team efficacy. In an economic climate of intense competition for staff, and a greater need than ever for cost efficiencies, the positive outcomes of psychological safety could provide vast benefits to the cotton growing industry. This CQUniversity and CRDC funded PhD project aims to explore psychological safety in the cotton farming context, and assess its utility in aiding the industry to build on its reputation as an 'employer of choice' so as to improve employee attraction and retention. Using a sequential mixed-methods approach the research consists of three phases: Phase 1 will use semi-structured interviews to explore the phenomenon of psychological safety among cotton farming teams. A theoretical model developed from the literature, will be adapted using the results of Phase 1 and quantitatively tested in Phase 2 via a large-scale questionnaire disseminated to a wider sample of cotton growing employees. In Phase 3, the results of the first two phases will be disseminated to key industry stakeholders via an online focus group to gain feedback on the model's utility and identify next steps for future research and application of the findings.

Drought resilient cotton: Developing a new biochemical understanding of developing drought resistant cotton.

G Dubey, R Sharwood, D Tissue, B J Atwell, D Sargent, W Conaty, Z Chen, B Choat
Hawkesbury Institute for the Environment, Western Sydney University

The severity and frequency of extreme climatic conditions such as concurrent heatwaves and droughts are increasing with every 0.5°C increment in global warming. These changing weather patterns severely affect cotton growth, development and productivity. Australia cotton industry is worth A$2 billion. The recent drought of 2018-2019 resulted in ~60% loss in cotton production than normal. Wild cotton relatives growing in hot and arid regions are genetically very diverse and we speculate that they harbour traits for resilience in drought and heat tolerance and could contribute to drought and thermotolerance in cultivated cotton. This project aims to investigate the effects of drought and heat stress on physiological, biochemical and molecular processes in diverse cotton species. The proteomic analysis will help in better understanding of the biochemical response of cotton to water deficits by identifying proteins that respond to drought stress as well as proteins that are only differentially expressed in drought-tolerant or sensitive genotypes. Collectively, this study will utilize the latest synthetic biology technologies to understand the role of aquaporins in water transport and CO_2 diffusion in cotton. This will provide insight into the thermal thresholds of drought recovery associated with water transport and provide new knowledge on the role of aquaporins to deliver improvements in water and CO_2 transport that can be utilized for developing more resilient cotton in future.

Untangling the Gordian Knot of breeding for resistance to Verticillium wilt Lucy Egan, Iain Wilson, Susie Thompson, Warwick Stiller Lucy Egan CSIRO Yield potential in Australian cotton is limited by the presence of Verticillium wilt. The introduction and improvement of host plant resistance (HPR) to Verticillium wilt has been a key breeding target for the CSIRO cotton breeding program for many years. However, significant challenges are associated with understanding and determining levels of resistance, including variation in pathotypes and interaction between the host, pathogen and environment. An update on the progress of breeding for resistance and novel phenotyping methods will be discussed.

Over-expression of P450 CYP6CM1 associated with resistance to imidacloprid in Australian *Bemisia tabaci* MEAM1.

Cao (Grace) Fang[1,2], Jacob Balzer[2], Jamie Hopkinson[2], Michael Frese[1,2], Wee Tek Tay[1], Tom Walsh[1]
[1]CSIRO, [2]Department of Agriculture and Fisheries, Queensland

The cotton industry is one of Australia's most significant contributors to the agricultural sector with exports worth around $2 billion per year. Cotton crops are regularly impacted by insect pests like *Bemisia tabaci*, commonly called the silverleaf whitefly. *B. tabaci* consists of a complex of phloem-feeding morphologically indistinguishable cryptic species. The invasive *B. tabaci* MEAM1 cryptic species was detected in Australia in 1994 and is now widely distributed. Neonicotinoids including imidacloprid have been successfully used to control whitefly in Australia, but cases of resistance in cotton have been documented. Using bioassay and molecular techniques, we investigated cross-resistance and resistance mechanisms in a known resistant MEAM1 strain. Bioassays were conducted using a field-isolated MEAM1 resistant strain and the results showed that cross-resistance was not equivalent with high resistance to imidacloprid and clothianidin, while resistance to acetamiprid was low, and the strain demonstrated no resistance to dinotefuran. We also used transcriptional analysis to investigate resistance mechanisms. The analysis showed up-regulation of the cytochrome P450 CYP6CM1 gene in the resistant strain compared with susceptible insects. The over-expression of P450 CYP6CM1 and its association with neonicotinoid resistance has been reported in overseas *B. tabaci* MED populations, however, it is the first time that such resistance mechanism is reported in Australia.

What can you see? Harnessing deep learning for cotton leaf hairiness phenotyping with HairNet2.

Moshiur Farazi, Warren C. Conaty, Lucy Egan, Susan P. J. Thompson, Iain W. Wilson, Shiming M. Liu, Warwick N. Stiller, Lars Petersson and Vivien Rolland
CSIRO

The hairiness of cotton leaves, due to the presence of trichomes on the leaf surface, is a key phenotype linked to yield, fiber value, and pest resistance. However, selection in the CSIRO commercial breeding program is currently based on visual scoring methods which are qualitative and subjective, often leading to ambiguity and limited reproducibility. In previous work, we have shown how recent developments in computer vision and artificial intelligence could provide a solution to these challenges by building HairNet, a deep-learning model able to reproduce the qualitative scoring assessment of breeders with 88% accuracy off a single image per leaf. In this presentation, we introduce HairNet2, a deep learning model designed to quantitatively measure cotton leaf hairiness. HairNet2 provides an objective measure of leaf hairiness by first identifying and then quantifying leaf trichomes. HairNet2 was put to the test using a wide-ranging dataset of over 20,000 cotton leaf images, collected over a period of four years, under different growth conditions, and across various experimental setups. HairNet2 consistently delivers a reliable measure of trichome hairiness that is not dependent on subjective assessment. This makes it a valuable tool for breeders,

ensuring consistent measurements of leaf hairiness compatible with genomic selection can be obtained, which will in turn assist in breeding more productive and pest-resistant cotton varieties.

Mapping cotton fields, predicting yield, and identifying yield limitations using scalable approaches for the Australian Cotton Industry.

Patrick Filippi, Dhahi Al-Shammari, Si Yang Han, Thomas Bishop
The University of Sydney

We are now in the age of digital agriculture, and there are incredible opportunities for the Australian Cotton Industry to capitalise on the wealth of data and analytical techniques now available. These opportunities have the potential to improve the understanding of our complex cotton cropping systems to deliver benefits to a range of stakeholders, from growers, agronomists, researchers, gins, and government agencies. This presentation will cover three different areas of research. 1) Mapping locations of cotton fields within-season across regions using remote sensing data. 2) Using high-resolution evapotranspiration (ET) remotely sensed data (CMRSET) to predict within-field and field cotton yield across large areas. 3) Identifying yield gaps and possible limitations to yield with boundary line analysis and high-resolution ET data. The latter piece of research has the potential to identify where overapplication of N fertiliser has occurred. Combining all of this research together would allow the industry to automatically detect where cotton is being grown, estimate the yield, and understand where limitations to production may exist. This combined research possesses a suite of positive outcomes for multiple different stakeholders – from the field to the further down the supply chain. This research relies on publicly available remotely sensed data and uses cotton yield monitor data, meaning that these methodologies could be realistically implemented across the whole industry.

Demonstrating and integrating irrigation technology for cotton.

Joseph Foley, Simon Kelderman, Malcolm Gillies
Centre for Agricultural Engineering, University of Southern Queensland

The last decade has seen a significant change in the amount of ag-tech and IoT deployed across irrigated broad-acre cotton fields that automatically optimise irrigation performance, relieve growers of tedious irrigation tasks, or simply provide more information for improved irrigation management decisions. By reflecting on the importance of irrigation performance measures, those that service the cotton industry may come to a fuller understanding of the necessary tools they and growers can now use in the irrigation management process. This presentation will provide an update on the range of technologies being deployed across irrigated fields by growers, irrigation consultants and technology companies assisting growers with the management of water on-farm, that enable improved water accounting at an enterprise level. The pipeline of future irrigation control technologies will be highlighted.

Fluorescently tagged *Verticillium dahliae* to understand the infection process on cotton and other plants.

Sabrina Morrison, Aphrika Gregson, Linda Smith, Elizabeth Aitken, **Donald Gardiner**
The University of Queensland

Verticillium is a soil borne disease caused by distinct vegetative compatibility groups (VCG) of the fungus *Verticillium dahliae*. Two VCGs, corresponding to the defoliating and non-defoliating pathotypes of Verticillium, have been transformed with Green and Red Fluorescent protein genes. The transformants maintained their ability to infect cotton and both strains were observed to colonise the xylem vessels of cotton plants. Moreover, we observed that the cotton Verticillium strains could also infect some sampled non-*Gossypium* species found in the Australian landscape. The fluorescently labelled strains of Verticillium will allow us to gain a thorough understanding of the infection processes of this important pathogen.

Why early season square retention rarely matters for high yielding Bollgard 3 In Australia.

Paul Grundy
Department of Agriculture and Fisheries, Queensland

Industry data indicates cotton crops are commonly sprayed twice during squaring to regulate retention. For operational convenience insecticides are usually applied simultaneously with glyphosate for weed management. However, not only is the economic benefit of this practice unverified, additional insecticide both disrupts integrated pest management and contributes to the industry's environmental footprint.

The impact of square loss in commercially grown high yielding Bollgard 3 fields was assessed from Emerald to Griffith over three consecutive seasons. In each field three square removal treatments (from fruiting branches 1-5, 6-10 and 1-10) were replicated with an undamaged control, and growth and yield component responses were measured.

For 33 out of 34 sites, total square removal from the first 5 fruiting branches prior to flowering had no impact on crop maturity, lint yield or quality. Compensation was rapid, occurring via additional bolls retained on sympodia immediately above or on distal fruiting positions adjacent to lost positions. Compensation was not reliant on additional mainstem node production, explaining the negligible impact on crop maturity.

The data has been used to revise industry recommendations for early season fruit retention that aim to balance the need to spray with the capacity of cotton to compensate square losses.

Innovative fibres, their economic viability, sustainability, threats, and opportunities - with specific reference to cotton.

Murray Hall, Colleen MacMillan, Sorada Tapsuwan and Stuart Gordon
CSIRO

Overall, a consumer's motivation to purchase textiles is multifaceted with price, quality, & verification of product attributes playing significant roles. As waste & ethical considerations gain prominence, consumers increasingly look for transparency & responsible practices in the products they use, & then discard. Life-cycle analyses & the Higg Index are commonly used to assess the sustainability of fibres & the textiles manufactured from them. However, application of these tools can have shortcomings. These include uncertainty about the extent of impact assessments & in particular a lack of transparency around the production, processing, & distribution economics of new fibres. A new CRDC project will examine cotton & the fibres it competes with including the array of new sustainable fibres. Scenario analyses & LCAs will be used to measure & compare fibres based on their production, processing, & distribution inputs including current end of life practice, as well as their potential for circularity. Limitations in data will be highlighted, as well as historical trade & technological contexts. The value of a fibre's sustainability attributes will be assessed by surveys to understand a consumer's willingness to pay for sustainability. The outcome of this project is intended to be a peer-reviewed publication describing the assumptions used in the LCA audit process, & the LCA outcomes for cotton & the range of standard & new fibres with which it competes.

Influence of seed characteristics and physiological quality on establishment vigour.

Hannah Hartnett
Cotton Seed Distributors Ltd

Establishment of an adequate and uniform plant stand is critical to maximising yield potential and avoiding the costly exercise of replanting. Along with field and climatic conditions, seed quality plays an important role in field establishment. The physiological quality of cotton planting seed supplied to the Australia cotton industry by Cotton Seed Distributors Ltd. (CSD) is already thoroughly tested using internationally recognised (ISTA, AOSA) standard testing protocols: the standard warm germination test for germination potential and the cool germination test for seed vigour. Varieties with a low density seed type now represent the majority of seed planted by Australian growers. It is well recognised that the compromise for the exceptional lint yield potential of these varieties is lower seedling vigour. While these varieties may still produce seed with excellent germination, they can still have issues with field establishment under less than optimal conditions. The current study has created a greater understanding of seedling vigour, including how it interacts with other quality parameters and its influence on field establishment in a range of conditions. Key outputs from the project include the identification of test methods to quantify seedling vigour and the ranking of current commercial varieties.

Closing the loop – developing circular pathways for cotton production systems by creating value options from cotton gin trash waste.

Simone Heimoana, Tianne Parker, Dee Hamilton
CSIRO

Cotton gin trash is a lignocellulosic farm waste product that may be useful as a substrate for growing oyster mushrooms (*Pleurotes* spp.). During this process the fibrous material is pre-digested and the spent mushroom compost may be useful as a dietary component for Black soldier fly (BSF) larvae. BSF provide high quality protein that could be utilised in aquaculture diets to replace soy or marine protein. We tested the two steps of this circular economy concept and found that it is feasible to grow oyster mushrooms on substrates that contain a proportion of cotton gin trash with differential effects on yield and fruiting period. MRLs of the most commonly used pesticides and growth regulators used in cotton production were not exceeded in any mushrooms produced. Further research would include the identification of substrate combinations to optimise yield and an economic analysis for scale. Spent mushroom compost (SMC), irrespective of the state of decomposition, was not a suitable dietary component for optimal BSF development but could be included at no more than 25% with additional protein. Despite good protein values in SMC, protein was a limiting factor as larvae were not able to utilise the protein. Future research into low value fibrous farm waste to upcycle protein should consider the biochemistry and digestibility of different protein sources and insect metabolism for compatibility.

Improving understanding of growth and development of cotton varieties.

Larissa Holland, Michael Bange, CSD Extension and Development Team
Cotton Seed Distributors Ltd

Effective monitoring of field crop performance requires detailed understanding of the differences in cotton varieties. Analyses of cotton growth and development was undertaken on the Cotton Seed Distributors Ltd. agronomic dataset (called ERICA) over 312 crops across six seasons. Key varieties assessed were Sicot 748B3F, Sicot 746B3F and Sicot 714B3F, all containing Bollgard 3® and Roundup Ready® genes. Varieties were assessed for differences in their responses of plant height, node, and boll development, timing of first flower, Nodes Above White Flower (NAWF) at first flower, length of flowering period, and the response of NAWF after flowering. Statistical analyses of the dataset were undertaken using REML and stepwise linear regression. The statistical analyses sought to identify specific differences in varieties, regions, and the interaction of varieties and regions. Plant height, node and boll development were related to day degrees and there were no differences when varieties and regions were considered. There were, however, differences in timing of flowering, NAWF at flowering, and the length of flowering. These outcomes have identified the key variables that will be measured with future varieties and will be used in decision tools like CottonTracker® to assist management.

Understanding *Spodoptera litura* larval survival in Bollgard 3 crops in Northern Australia.

Sharna Holman, Michael Furlong, Paul Grundy and Helen Spafford
Department of Agriculture and Fisheries, Queensland, University of Queensland, Department of Primary Industries and Regional Development, Western Australia

The introduction of Bt cotton has facilitated industry expansion into regions historically burdened by high insect populations. Since experimental farming of Bollgard 3 commenced in Northern Australia in 2017, there have been frequent reports of *S. litura* larvae of all instar sizes surviving in some crops. Effective pest and resistance management relies on a comprehensive understanding of pest biology, ecology and host-plant interactions. However, due to its rarity in Australia's temperate climates, little is known about *S. litura*, hindering the development of sustainable management practices. Investigating factors associated with larval survival in Bollgard 3 crops marks the initial step in assessing the pest status and resistance risks posed by *S. litura* in cotton across Northern Australia. Here we discuss a series of experiments exploring various mechanisms that potentially facilitate improved larval survival, including plant phenology and different plant parts.

AI Classifier to Enable an Auto-Calibration System for a Gin-Stand Based Machine-Vision Inspection System for Plastic Contamination.

Mathew G. Pelletier, John D. Wanjura and **Greg A. Holt**
USDA-ARS, Cotton Production & Processing Research Unit

The U.S. cotton industry faces a significant challenge in removing plastic contamination from cotton lint, largely caused by the plastic wrappings employed during cotton module production. To tackle this, a machine-vision detection and removal system has been designed. Utilizing affordable color cameras, the system can identify and discard plastic from the cotton flow. However, this system's complexity, which involves the use of 30-50 low-cost computers, necessitates extensive calibration and presents operational difficulties for the typical cotton gin workers.

Our current research project aims to refine this system, transforming it into a more accessible and user-friendly device. The introduction of an AI-based auto-calibration feature is a key aspect of this transformation. It will enable the system to dynamically track cotton colors while avoiding plastic images, which could otherwise compromise the calibration process. This advancement would not only reduce the dependency on highly skilled personnel but also ease the system's integration into the cotton ginning industry, thus streamlining the process of plastic removal from cotton lint and enhancing the adoption of a plastic removal system within the cotton ginning industry. This presentation provides information on data gathered from 10 machine vision systems at two commercial gins during the 2022 cotton ginning season.

Orienting and rotating round modules to reduce plastic contamination risk.

J.D. Wanjura, **G.A. Holt**, M.G. Pelletier, E.M. Barnes
USDA-ARS, Cotton Production & Processing Research Unit

A round module handling system for use on wheel loaders and telehandlers was designed to provide module specific identity, ownership, weight, and moisture content information when the modules are engaged by the machine. The system is also capable of rotating modules into a pre-determined orientation based on RFID tag location and sequence using an automated positioning routine in the custom written software or via manual hydraulic control. The goal of reorienting and rotating modules before ginning is to reduce the occurrence of improperly placed fixed position/manual cuts of the module wrap that increase the risk of plastic contamination. Results of field testing to document system performance and reductions in potential plastic contamination events identified on a cotton module feeder will be discussed.

Resistance to spirotetramat in silverleaf whitefly. What's happening in cotton?

Jamie Hopkinson, Jacob Balzer, Grace Fang, Tom Walsh
Department of Agriculture and Fisheries, Queensland, CSIRO

Silverleaf whitefly (Bemisia tabaci) are a major pest of many crops with a capacity to evolve resistance to insecticides that has made managing them challenging. Spirotetramat (a Group 23 insecticide) was first registered for use in Australia in 2009, and annual surveillance for resistance in whitefly commenced shortly thereafter, with the initial detection in 2016 from the predominantly horticultural regions of Ayr and Bowen. Resistant individuals were first recorded in cotton during 2019 and while resistance remained low and rare for several seasons, our most recent surveillance data shows the presence of resistant populations in cotton is becoming more widespread.

In this presentation we will discuss how both bioassay and genomic approaches have been used to detect resistance to spirotetramat and explore options that could be adopted to manage the evolution of resistance to spirotetramat and other insecticides in the cotton industry.

A private/public sector collaboration to address FOV.

Don Jones, Chris Saski, Stephen Parris, Jim Olvey, Mike Olvey, Jeremy Schmutz, Avinash Sreedasyam, John Lovell
Cotton Incorporated

Fusarium wilt, specifically FOV4, is a threat to Upland cotton in the US. Before FOV4 hit California, Upland cotton production there exceeded 2M acres. However, due to the infestation, Upland cotton is now grown on less than 100k acres in that state, a result that is permanent since growers have shifted to almonds and pistachio. However, in the rest of the US cotton belt, should FOV4 spread, alternative crop options are not nearly as readily available. Durable genetic resistance using DNA informed breeding strategies is the only viable solution to FOV4. This presentation will summarize the collaborative effort that melded the molecular/genetic skills from two public sector lab staffs with proprietary phenotyping protocols of our private sector collaborator. Results to date include: 1) highly resistant FOV4 germplasm such as U1, U2, U3, and U4; 2) identification of causative genes and associated markers, 3) reference grade genome assemblies of U1 and commercial variety Siokra250 which is resistant to the Australian FOV but susceptible to FOV4, and 4) development of F8 RIL biparental derived inbred populations that segregate for US FOV4 and possibly the Australian FOV isolate, laying the groundwork for future US/Australian collaboration.

Plant-parasitic nematodes, a threat to Australian cotton?

Dinesh Kafle, Linda Scheikowski and Linda Smith
Department of Agriculture and Fisheries, Queensland

Plant-parasitic nematodes are the number one cotton disease in the USA that accounts for a loss of more than 550 million bales of cotton in 2022. The reniform nematode is widespread in the Central Queensland region. QDAF monitors the status of the reniform nematodes in various cotton-growing regions, although there is no economic study that estimated the yield loss caused by nematodes in Australia. In recent years, cotton seedlings with very weak and rotting root systems have been noticed in reniform nematode-infested fields, and reniform nematode is also suspected to play some detrimental role in such poor roots. Reniform nematodes have also been found infecting the root system of mungbean which is a common rotation crop that also grows as a volunteer crop in cotton fields. There are no nematicides or resistant varieties against reniform nematodes. Our glasshouse trial has shown that the silicon-treated seedlings are resistant to the reniform nematode which require further exploration. QDAF has been providing technical support to collaborating partners such as CSIRO and Bayer to conduct field trials for the management of reniform nematode. There is a strong need for future research on monitoring of nematode population, yield loss caused by nematodes, resistant varieties, rotation crops with the ability to reduce nematode population in the soil, field hygiene, and plant defence-mediated resistance for the sustainable management of plant-parasitic nematodes.

Exploring a cotton and grains agricultural apprenticeship model.

Amy Cosby, **Nikki Kelly**, Melissa Sullivan, Nicole McDonald
Central Queensland University, Australia

There is a significant current labour shortage across the Australian agricultural industry. While enrolments in agriculture university degrees have increased recently, this same trend has not occurred in vocational education and training courses. The 'Exploring a cotton and grains agricultural apprenticeship/traineeships model' project is investigating how Vocational Educational Training (VET) and formal apprenticeships/traineeships can be utilised to support viable pathways for school leavers and career changers in the cotton and grains industry. Interviews with key stakeholders in QLD and NSW have included government departments, RTOs, cotton and grain growers and young people in entry-level positions in the cotton, grain and other agricultural industries. Interviews sort to identify barriers, pathways and opportunities to increase the number of apprentices/trainees employed by cotton and grain growers whilst undertaking tailored training. The perception of current training options and issues with attracting apprentices/trainees is also being explored. This presentation will present the preliminary results of the stakeholder interviews. These results include a potential model for a broadacre cropping apprenticeship going forward, the challenges identified by key stakeholders to implementation, and possible solutions to achieving a training model that is not only attractive to a future workforce, but also meets the diverse needs of employers and farming operations.

Soils – their health, myths and sustainable future.

Oliver Knox (*Plenary*)
University of New England and CottonInfo

Soil health is something that most of us have heard of, but what does it actually mean? Against a background of an increasing body of literature on the subject and a national soil strategy promise of indicators to measure it, we proposed a sustainable soils framework in 2022 that has the potential to go beyond our cotton fields. The driver for this was an acceptance of what we know of our Australian soils, placing scientific evidence over beliefs and, most importantly, to provide something that our growers could easily embrace. With 2023 being the year where the FAO is reminding us that soil is where food begins, why not come on a journey of exploration, discovery and realisation with Oliver Knox (UNE), which might just help you better appreciate the dirt beneath your feet for the fragile and phenomenal ecosystem that your soils are. Who knows, you might get so excited that you may end up soiling your undies.

A baseline assessment and survey of weeds and weed management systems in northern cotton regions.

Eric Koetz and Graham Charles
NSW Department of Primary Industries

Cotton production in northern Australia looks to be an important expansion for the industry. However, the northern cotton industry has a number of risks which include the potential for soil and residual herbicides to contaminate rivers and the reef, and for northern weeds to develop herbicide resistance. Heavy reliance on glyphosate now, along with the potential introduction of new herbicide traits and the potential reliance on the associated herbicides, means that the maintenance of diversity in the system continues to be crucial for sustainable and profitable farming. These issues are magnified in the new northern cotton areas where weeds are growing under tropical conditions (potentially allowing multiple generations of weeds each year), and soil type and proximity to sensitive areas, including the barrier reef, makes it very challenging to use many of the older residual herbicides. It is essential to understand the issues around weeds in the north to enable a management plan to be developed for this area. A project with funding from CRDC and NSW DPI to undertake a base-line assessment of weed pressure via field surveys and face to face meetings with agronomists and growers in the emerging cotton regions of the Northern Territory, Far North Queensland, and the Ord region in Western Australia has commenced.

Alternaria alternata causes distinct foliar symptoms on cotton in New South Wales.

Chi PT. Nguyen and **Duy P. Le**
NSW Department of Primary Industries

Foliar disease has been long considered a minor one in cotton in New South Wales (NSW). However, a number of foliar disease outbreaks were reported on cotyledons and mature leaves in the past few seasons. Alternaria alternata was identified as a predominant pathogen associated with the outbreaks. However, during our annual cotton disease surveillance, we noticed distinct spot and blight symptoms exhibited on both cotyledons and leaves, which was possibly due to either different pathogens or host responses. We used sequence data of the internal transcribed spacer and translation elongation factor and identified A. alternata as a main fungus that was recovered from the two distinct foliar symptoms. We found a certain degree of intraspecific variations in growth rate, fecundity and spore germination. Most tested isolates grew best at 25 °C, except for one which grew best between 25 - 30 °C. This isolate also produced the highest number spores and number of germinated spores on potato dextrose agar. In pathogenicity assays, blight-symptom isolates appeared more virulent than spot-symptom isolates. We speculate this could be associated with a toxin that each isolate produces; therefore, this warrants a further investigation to elucidate the cotton-A. alternata population diversity and biology. We also assessed virulence of these isolates on three different cultivars, including 714B3F, 746B3F and 748B3F. We found virulence and disease expression were cultivar dependent ($p < 0.001$),

Gene editing in cotton, what is it good for?

Xiaoqing Li, Qian-Hao Zhu, Danny Llewellyn, Filomena Pettolino, Haylee Martin, Jackie Oliver, Iain Wilson
CSIRO

Gene editing enables highly specific DNA modification of an organism, with CRISPR/Cas9 being the most widely adopted system because it is simple, efficient, and accurate. CRISPR/Cas9 based gene editing can effectively mutate specific genes and their homologs, and therefore, is a powerful and convenient tool to investigate gene function and potentially develop new traits in cotton. We will review the gene editing landscape in cotton and discuss our work that is using gene editing to understand the function of a gene and its homologues potentially involved in fibre formation.

New ways to measure old traits: a case study in cotton biomass dynamics.

Xuesong Li, Connor Cassidy, Louise Zemcevicius, Alan Thompson, Shiming Liu, Warwick Stiller, Eric Stone, Lars Petersson, Warren Conaty, Vivien Rolland
CSIRO

The CSIRO cotton breeding program develops new cotton varieties based on an ever-improving package of competitive traits. For key traits such as yield and fibre quality, existing phenotyping methods are effective. However, recent studies have highlighted increased biomass production and improved radiation use efficiency as avenues for continued yield progress in cotton. While these traits are physiologically important, at present they cannot be measured with the accuracy and scale required by a breeding program. This talk will present how we are harnessing recent advances in cutting-edge technologies, such as AI and computer vision, to develop an automated and non-destructive method to measure cotton biomass at the scale required for breeding programs and agronomic research. We aim to provide researchers with an accurate and efficient tool to enable the measurement of growth and biomass dynamics, and remove current limitations around the measurement of traits such as seedling vigour, growth rate and radiation use efficiency at scale.

Can A.I. select cotton lines suited for different environments?

Zitong Li
CSIRO

Plant breeding aims to improve a crop by selecting plants with desirable traits based on field-based assessment. In cotton, the focus is on selecting elite lines according to economically important traits such as fibre qualities and yield. Traditional phenotype-based breeding has proven to be successful in Australia to select cotton varieties, but the high cost of field research restricts the ability to test cotton trials in multiple environments (i.e. various years and locations). Genomics prediction (GP), as an emerging data driven technology for plant breeding, provides an opportunity to predict phenotypes or breeding values of cotton based on both DNA and environmental information. GP is potentially able to reduce the breeding cycle and evaluate the phenotype performance of cotton lines in multiple environments. Based on trait data, DNA and environment information collected on more than 3000 cotton lines over a number of seasons, we have developed artificial intelligence (A.I.) and machine learning (M.L.) methods such as high dimensional regression models that can accurately predict important cotton traits.

Putting cotton in the spotlight in agricultural education.

Derek Long
University of Southern Queensland

Australian cotton researchers perform world leading research in the realm of digital agriculture, which includes smart sensing, big data analytics, and machine automation. The cotton industry relies on a steady flow of new technicians, scientists and engineers to maintain its position as a hub for innovation – a need which is serviced by a wide range of extension activities. Universities are supporting this extension by incorporating cotton-focused examples and applications into their agricultural courses, and recently in digital technology courses as well.

This paper will outline how the current digital agriculture research in the cotton industry is being used to create accessible and engaging activities for both university and school students. Examples of activities will be drawn from UniSQ's new Bachelor of Agricultural Technology and Management to show what the opportunities and barriers are in attracting digital technology students to agriculture.

New approaches to improving water productivity in cotton.

Annelie Marquardt, Philippe Moncuquet and Warren Conaty
CSIRO

Water stress is the most significant abiotic stress factor limiting cotton yields globally. The Australian cotton industry can be future proofed from the threats of climate change and reduced irrigation water access through developing varieties that result in relatively high yield under water-limited conditions. This goal will rely on the identification of water productivity mechanisms within existing cotton genotypes to serve breeding programs to improve drought tolerance. One mechanism that has been identified in numerous plant species is the reduction in the rate of transpiration in response to soil drying. Recently, cotton has been shown to display genotypic variability in the soil water threshold at which transpiration begins to decline. This strategy enables sustained crop productivity in prolonged water deficit conditions. However, little is known of the genetic factors involved in this trait. Through 'omics data analyses we investigate differences between cotton varieties that respond earlier to soil drying than others, in the hope of uncovering the genetic factors contributing to this trait. Ultimately, we aim to use this information by incorporating into genomic prediction models to develop cotton varieties optimised for the partially irrigated and dryland production systems of the future.

Artificial intelligence: what is it and what does it mean for cotton?

Alison McCarthy and **Derek Long** (*Plenary*)
University of Southern Queensland

Artificial intelligence has rapidly evolved into use in everyday tools and is enabling smarter decision-making and analytics across all industries including agriculture. This presentation will give an overview of how artificial intelligence works, and considerations, examples and opportunities for use in agriculture and particularly cotton, for example for sensing and machine vision.

Extensive validation of the BARRY model for the 2021-22 season

Craig McDonald
Cotton Seed Distributors Ltd

Data has been collected for six seasons through the Ambassador Program. This has included some very bad drought years with extensive heat wave conditions. BARRY has been built and validated extensively for 4 years predominately using drought years. There is an opportunity and a need to validate BARRY for the 2021 2022 season as it is characteristically different from the seasons used to build BARRY. There is also an opportunity to assess the ongoing performance of BARRY with the E&D team and the cotton industry and help consolidate confidence in the model and give the team an update on its accuracy. A written report and a presentation have been prepared with the findings from the study.

Utilising Research to Address the National Agricultural Workforce Strategy for the Australian Cotton Industry.

Nicole McDonald, Melissa Sullivan, Saba Sinai, Zhanae Dodd, and Amy Cosby
Central Queensland University

The Cotton Research and Development Corporation has been investing in workforce research for several years, with projects investigating job satisfaction, work engagement, workforce retention and turnover, and the future of work in the Australian Cotton Industry. When the National Agricultural Workforce Strategy (NAWS) was released in 2020, there was already significant evidence base to draw on to effectively address workforce attraction, development and retention on-farm, although gaps in knowledge remain. These gaps include answering research questions such as (a) how do we effectively identify good people management practice and support practice improvement with regards to workforce development, and (b) how do we address diversity and inclusion to achieve positive outcomes for the industry? This presentation will discuss two ongoing CRDC research projects, (a) The SHIFT Project which aims to support cotton growers with their workforce development, and (b) the Opportunities for greater diversity in the cotton workforce project, a scoping study which aims to explore how diversity and inclusion is practiced, perceived, and valued in agriculture. The NAWS noted that "… agriculture needs all available talent and the diversity that comes with it." (p. 32). These two projects provide an effective evidence base to understand the context-specific challenges and offer tools and strategies to improvements that can give the Australian Cotton Industry a competitive advantage when it comes to securing the adaptable, engaged, and skilled talent we need. While technological developments, innovative science backed production practices, and the acceptance and adoption of these on-farm are essential for the future sustainability, productivity and profitability of the industry; understanding people, and applying our research efforts from the fields of psychology, education, business, and sociology, are vital to delivering strategic workforce interventions that act as catalysts to advance our industry and ensure we are continuing to lead.

The trends of water productivity and water sustainability indicators for Australian cotton from the benchmarking program.

Malem McLeod, Jasim Uddin, Sarah Dadd, Ben Crawley, and Peter Regan
NSW Department of Primary Industries

The Australian cotton industry must show both sustainable and productive water use because water availability for irrigation is declining. This paper presents trends of water productivity and water sustainability indicators assessed for the industry since 1997.
The gross production of water use index, GPWUI (bale/ML), is the established water productivity indicator used by the Australian cotton industry. The sustainable water use index, SWUI (ML/bale), is used to show how much water is used to produce one bale (227 kg) of cotton lint.

The average GPWUI for Australian cotton has increased from 0.62 bales/ML in 1997 to 1.22 bales/ML in 2021 and is steadily approaching the industry's 2023 target GPWUI average of 1.32 bales/ML. The annual rate of GPWUI increase between 1997 and 2007 was 8.2% but it has been slowed to 0.6% since 2007. The global data on cotton water productivity is rarely available. However, the annual average GPWUI for Australian cotton for the 1997-2021 period is consistently above the global average data available, which is 0.48 bales/ML.

The amount of water used to produce one bale of cotton (SWUI) in 2021 is 52% less than in 1997, falling from 1.68 ML/bale to 0.80 ML/bale. It is also consistently below the global average data available, which is 2.07 ML/bale equivalents.

These improvements are the result of increased yield and irrigation efficiency, reduced water inputs and rainfall.

There is scope for growers to increase their water productivity.

The cotton genome puzzle: The value of connecting the pieces.

Philippe Moncuquet
CSIRO

Over the past 25 years, there have been remarkable advancements in accessing and understanding genomic information, leading to profound transformations in life-science research. Starting from the initial draft of the Drosophila genome in 2000, the past two decades of innovation have profoundly reshaped genomic research. Following suit, there has also been significant advancements in genomic research in cotton. Approximately ten years ago, the first reference genomes of Gossypium raimondii and Gossypium hirsutum were made available. Since then, researchers have utilized the information derived from these (and more recent) genome references to gain valuable insights from various omics cotton datasets. By linking genetic information to traits of interest, researchers now have access to new tools and methodologies. The advent of long-read sequencing provided another quantum leap in the field, providing cost-effective access to genomes. With the continuous characterization of numerous cotton genomes, exciting new research opportunities and applications are emerging. The primary objective of the CSIRO cotton breeding program is to cross genomes and develop elite varieties that meet industry expectations in terms of yield, fibre quality, and disease resistance. In this talk, we will present our efforts in this area and showcase our initial attempts at assembling the genomes of our cotton breeding lines. Additionally, we will provide a glimpse into the future and delve into the potential applications of panomics in the context of the cotton breeding program.

Palaeochannel spaghetti: Within-field soil and cotton yield variability on southern NSW palaeochannel systems

Jonathon Moore, Stephen Cattle, Patrick Filippi
The University of Sydney

Soils of the lower Murrumbidgee valley in southern NSW have resulted from the alluvial deposits of four temporally and spatially distinct palaeochannel systems. These systems exhibited deltaic characteristics and high stream loads, their form and course unrelated to the modern river system. The interaction of these palaeochannels results in diverse, highly variable soils. This research seeks to understand the impact of within-field soil variability on cotton yields across different palaeochannel systems. Three irrigated paddocks with known soil variability were chosen near Darlington Point, Carrathool and Hay. In each paddock production zones were created with soil cores extracted to a depth of 1 metre at selected sites within each zone. Cores were subset for the depths of 0-10, 10-30, 30-60, 60-80 and 80-100 cm with laboratory analysis undertaken to determine inherent soil properties. Analysis showed significant variability in soil properties at the same depth within each paddock. Point data exhibited strong correlations (>0.5) between soil properties and cotton yield. The strongest correlations were at the 60-80 cm depth with Cation Exchange Capacity having a 0.94

correlation at the Hay site. A significant difference in soil texture was observed between production zones, with a higher sand content significantly decreasing yield. Linear mixed models were used to produce digital soil maps of selected soil properties allowing for observations of within-field variability.

How does diseases in cotton are managed in India, the leading producer?

Karthikeyan Muthusamy, Johnson Iruthayasamy, Sambasivam Periyannan
Tamil Nadu Agricultural University, India, University of Southern Queensland, Australia

India is a leading producer of cotton in the world with 26.44 MT (2021-22) and accounts for 26% of the global production. Cultivars belonging to four *Gossypium* species (*G. arboretum*, *G. barbadense*, *G. herbaceum* and *G. hirsutum*) are grown in South while three species except *G. barbadense* in central when *G. arboretum* and *G. hirsutum* are the widely adopted species for the Northern part of India. Sadly, the area under cotton is declining since 2019 and the productivity is hampered by fungal diseases including, anthracnose (*Colletotrichum indicum*), Alternaria leaf spot (*Alternaria macrospora*), Corynespora leaf spot (*Corynespora cassiicola*) grey mildew (*Ramularia areola*), sooty mold (*Capnodium* spp.) and blackarm, wilt (*Fusarium oxysporum* and *F. vasinfectum*) and root rot (*Sclerotium rolfsii* and *Rhizoctonia solani*) while bacterial disease is represented by the blight (*Xanthomonas malvacearum*). Among the viral diseases cotton leaf curl is of significant threat. Fungicides used consist of Propiconazole (sooty mold), Pyraclostrobin and Carboxin+Thiram (Alternaria leaf spot), Kresoxim-methyl, Fluxapyroxad+Pyraclostrobin, Azoxystrobin+Difenconazole and Captan+Hexaconazole (boll rot and foliar diseases). For viral diseases, the white fly vector is managed using Flonicamid. Efforts has also been made to use bioinsecticides derived from *Lecanicillium lecanii*. Seed and soil treatment with *Trichoderma* spp. (Rf-B/Th-11 isolate) as a default practice significantly minimizes wilt and root rot.

Are we sustaining wellbeing in the cotton industry and cotton communities?

Jacki Schirmer, **Melinda Mylek**
University of Canberra

Worldwide, sustainability frameworks are increasingly used to understand whether industries are sustainable. Relatively few have incorporated measures of wellbeing as part of understanding sustainability - but increasing evidence shows that achieving a sustainable workforce requires investing in quality of life both in the workplace, and in the community a person lives in. This paper reports findings from a project that explored potential measures of wellbeing-focused sustainability in the cotton industry, and recommendations for measuring wellbeing-related sustainability indicators into the future.

Legacy effects of soil compaction on cotton and wheat crops in Vertosols: Insights from a field experiment.

Guna Nachimuthu, Blake Palmer, Hiz Jamali, Andy Hundt, Stacey Cunningham and Graeme Schwenke
NSW Department of Primary Industries

Soil compaction commonly impacts productivity in Australian cotton production systems. Previous controlled environment research using intact soil cores found that it can take several wetting and drying cycles to alleviate compaction in Vertosols with swelling and shrinking nature. A field experiment conducted during the 2019-20 season showed that compaction decreased lint yield by 27% and reduced crop water use at 30-50 cm depth by 72%. We monitored the subsequent crops (wheat 2020; cotton 2020-21; wheat 2022) for potential legacy effects of soil compaction. There was no legacy effect of soil compaction on the grain yield of the 2020 wheat crop. The lack of difference in wheat yield could be the result of sufficient rainfall recharging the soil profile during the growing season to overcome limitations of deeper soil water extraction due to compaction. There was also no effect of soil compaction on the lint yield of the 2021-22 cotton crop. The soil resistance measured at a similar soil water content also showed no lasting impact of soil compaction in 2021-22. The self-repair properties of high-clay (63%) Vertosols during wetting/drying cycles likely assisted the natural and wheat rotation-mediated alleviation of soil compaction. This research should be expanded to incorporate a greater range of soils and rotation crops typically used for irrigated cotton production, focusing on the time and number/depth of wetting/drying cycles required to repair the compacted soil.

Southern NSW Grower groups – the key to adoption of best practice.

Kieran O'Keeffe
CottonInfo

Two pilot cotton grower groups were formed in the 2021/22 season at IREC field station Whitton and Coleambally Demo farm. Twenty five growers have regularly attended these discussion group meetings, in the field, at Establishment, First flower, Last Effective flower, Defoliation and End of season wrap up. Growers selected one of their fields to be entered in the CSD C Crop Optimisation tool and have provided seasonal crop data at the meetings.

Feedback from participants has been very positive. Growers can compare management practices, where their crop is up to and discuss with the team critical management decisions. Growers use the meeting to raise their own questions on topics such as nutrition timing and rates, integrated pest and weed management, variety choice and planned rotations for next season. It allows direct contact between the CSD extension team and a group of growers face to face so key points can be reinforced. The growers are much more comfortable in smaller discussion groups to talk about their crop and learn from other growers and the extension team.

The challenges and opportunities of molecular resistance monitoring: A case study in *Helicoverpa armigera* Bt resistance

Amanda Padovan, Kristen Knight, Susan Maas, Nicola Cottee, Graham Head, Tom Walsh and Sharon Downes
CSIRO

Effective resistance management is critical to the success of Bt cotton in Australia and monitoring the insect populations for resistance is important for achieving this outcome. Resistance monitoring currently relies on expensive and labour-intensive bioassays. Molecular resistance monitoring offers many advantages to bioassay-based monitoring, such as higher throughput, less hands-on time and less dependence on insect biology. We developed two molecular resistance monitoring tools that can support the bioassays: a PCR based method to detect known resistance alleles, like an F1 bioassay; and a whole genome sequencing based method that can be used to detect novel resistance alleles, similar to an F2 bioassay. The PCR method is very effective at detecting known Cry2Ab resistance alleles, however these alleles are not very common across the landscape. The whole genome sequencing method is also effective at detecting known resistance alleles, and provides a unique database for retrospectively investigating frequencies of novel resistance alleles, e.g. the dominant Cry1Ac resistance allele identified in Chinese populations and an unpublished Vip3A resistance allele found in Australian populations. These findings suggest that the current resistance management plan is very effective at delaying Bt resistance in *Helicoverpa armigera*. Here, we discuss the challenges of implementing molecular resistance monitoring and the opportunities for expanding to other systems.

Benefits of a sprayable mulch in dryland cotton systems

***Harry Paine**, Sandra Williams, Stuart Gordon*
The University of Sydney, CSIRO

Dryland cotton production systems are inherently constrained by three primary variables: glyphosate-resistant weeds, temperature, and moisture. Glyphosate-tolerant cotton systems are experiencing incidental increases in weed resistance, necessitating new options for integrated weed management. Another major constraint is cotton's thermally driven nature, requiring soil temperatures to be consistently above 14OC to allow successful establishment. In cooler regions, growers are forced to sow later, constraining yield potentials. Soil moisture is critical for cotton yields, governing yields through boll development and when cut-out occurs.

The recent development of a sprayable, biodegradable polymer mulch demonstrates potential to simultaneously improve soil moisture retention, temperature stabilisation and weed suppression. A field trial using a randomised block design with three treatments, a control, 1 kg/m2 and 2 kg/m2 was used. To assess weed suppression, Japanese millet was used as a surrogate weed. Soil temperature and moisture probes collected measurements at 30-minute and hourly intervals, respectively. For temperature, temperature was converted into thermal time using the 1532 day-degree system to illustrate the agronomic effects of the mulch on soil temperature.

Overall, the mulch demonstrates significant potential to improve dryland production. Most notably, accumulated thermal time and weed suppression was highest under the 2 kg treatment, but differences were not significant. Changes in moisture retention were not observed. Despite no significant differences, the high variability in observations is likely due to the soil's shrink-swell properties, resulting in a gradual disintegration of the mulch's insulative effect over time. Further study on varying soil types is necessary of cotton production systems to fully assess the potential of this sprayable mulch.

Does foliar nutrition help cotton crops overcome waterlogging?

Blake Palmer, Guna Nachimuthu, Stacey Cunningham, Andy Hundt, Graeme Schwenke
NSW Department of Primary Industries

Australian cotton is mainly grown on Vertosols which are susceptible to waterlogging due to their high water holding capacity and poor drainage. Waterlogged soils are quickly depleted of oxygen, which can affect soil properties such as pH and redox and impact nutrient availability and root growth. Foliar nutrition sprays are often proposed to mitigate flood-induced poor nutrient uptake. This study investigated whether foliar nutrition sprays applied after waterlogging could improve cotton growth and yield during 2021-22 season. Treatments were T1 - control (distilled water), T2 – urea ammonium nitrate, T3 – mono ammonium phosphate, T4 – zinc sulfate and T5 – multi-nutrient blend of N, P, K, Ca, Mg, S, Cu, Mn, Fe, Zn, B, Co and Mo. Treatment effects were determined by measuring lint yield, fibre quality, crop biomass, NDVI, groundcover (%) and disease incidence (%). Results indicated no significant difference (P < 0.05) on any assessed parameters between treatments. Average yield was 10.9 bales/ha and, likely due to seasonal conditions, disease incidence was high (38% of plants). Foliar nutrition applied after a flooding event which occurs while cotton is at the vegetative stage is unlikely to benefit cotton growth. Past studies have indicated that a pre-waterlogging foliar nutrition application may improve crop performance. Other management practices (e.g. reduced tillage to improve soil structure) may assist in post-flood crop recovery.

Better than 20/20 vision: the role of AI in disease phenotyping.

Manish Patel, Lucy Egan, Vivien Rolland, Geoff Bull and Warren Conaty
CSIRO

Verticillium wilt (VW) poses a significant challenge to the Australian cotton industry. While it is almost impossible to have an accurate understanding on the impact of the disease, it is estimated that approximately one in four field are infected with the pathogen and the disease can result in yield losses of up to 50%. The development of germplasm with host plant resistance to VW is one avenue for the control of the disease. Therefore, the CSIRO cotton breeding program has a significant focus on the development of varieties with improved resistance to VW. However, the accurate detection and quantification of VW is pivotal in identifying resistant germplasm. The current method for assessing disease resistance largely involves manual counting of plants infected with the disease through visual observations of vascular browning. This method has limitations including the high cost of the labour for manual scoring, operator bias in scoring and complexities around up-scaling of phenotyping efforts. Recent advancements in computer vision and deep leaning offer a new avenue in developing VW detection models, which may also be expanded to quantify the severity of disease. These methods are rapid, scalable, and once established should have lower running costs. This presentation will highlight the promising progress, and associated challenges, of a deep learning model for the detecting VW in field-based cotton stems.

Characterising nitrogen-water interactions in cotton bankless channel surface irrigation systems.

Wendy Quayle, Rodrigo Filev Maia, Jackie Webb John Hornbuckle
Centre for Regional and Rural Futures, Griffith, Deakin University

Modern bankless channel surface irrigation layouts and farm water delivery systems offer more accurate application of water at lower labour costs than has ever been possible before. Since fertilizer nitrogen use efficiency is highly dependent on irrigation management through the uniformity and distribution of water in soil, new bankless channel systems could also offer the control necessary for cotton growers to more accurately apply nitrogen, improve its availability to plants and minimise over-supply that can lead to environmental losses and excessive costs. This study is evaluating the current overall efficiency of N in flat dual inlet and graded bankless channel layouts applied to cotton by ground rig and water run urea methods according to seasonal conditions and plant growth. Characteristics of irrigation uniformity and application efficiency are related to NFUE by field measurement of furrow water advance, recession and dissolved nitrogen in individual irrigation cycles. Information of soil mineral N, plant N uptake and nitrous oxide losses to the atmosphere will be discussed.

Exploiting GxE interactions to advance rainfed cotton yield.

Pierce Rafter, Zitong Li, Iain Wilson, Warren Conaty
CSIRO

Traditional rainfed cotton production systems in Australia are primarily limited by water availability. In comparison to irrigated cotton production systems, these systems have no control over the quantity and timing of water supply. Consequently, these rainfed cotton systems yield significantly less than irrigated production systems. Understanding the interplay between cotton performance and the magnitude and timing of different environmental conditions is important from a management perspective, but it is also important from a breeding perspective where the objective is to identify genetically elite lines. Yield is determined by the interaction of environmental and genetic effects, so accounting for weather conditions (environment) should result in more accurate estimates of genetic effects. We aim to determine the relationship between rainfed cotton yield and quality traits with environmental variables, such as rainfall, solar radiation, ambient temperature, and humidity. This information will be used to better understand genotype x environment interactions (GxE) in rainfed cotton production systems, and ultimately will be deployed in genomic prediction models that use genetic and environment information to predict variety performance.

Diagnosing agrochemical ‘drift’ injury through leaf tissue analysis – what have we learnt?

Michael Rose, Stacey Cunningham, Brad Keen, Blake Palmer, Andy Hundt, Kelvin Spann, Guna Nachimuthu
NSW Department of Primary Industries

Herbicides and defoliants are widely used in various Australian agricultural industries. During and after spray application, a small proportion of the chemical applied may move off-site by aerial transport (hereafter referred to as ‘drift’). Whether or not this drift poses a risk to nearby native vegetation or crops depends on the amount lost, potential atmospheric dilution, processes that affect bioavailability (e.g. binding to aerosols) and the sensitivity of the plant exposed to the deposited chemical.

Despite ongoing education and improved practices to reduce drift, there are still reports of suspected spray-drift injury to cotton, other crops and native vegetation. Determining the exact cause of these injuries remains a challenge, since symptoms may not be unique to herbicide damage and could be a consequence of other biotic (e.g. pathogens) or abiotic (e.g. frost, nutrient deficiency) factors. In recent experiments we have sought to determine whether leaf tissue testing for herbicide or defoliant residues can overcome this uncertainty, by linking residue concentrations to injury symptoms and thresholds. In this talk we present information from several case studies examining simulated drift of 2,4-D onto cotton; dicamba onto mungbeans and cotton defoliants onto native tree seedlings. We will discuss the technical and logistical challenges associated with measuring herbicide and defoliant residues in leaf tissue, and how leaf tissue data can be interpreted.

Llara – A dryland cotton farm and biodiversity case study

Roth G, Bateman J, Wardle G, Greenville A, Dahlem M, Whitehouse M, Marshall D**, Pearce K*.
The University of Sydney

Farm sustainability is crucial for the cotton industry. Biodiversity is a key aspect of sustainability frameworks that have proven particularly challenging to validate. Biodiversity is an indicator of farm health and provides ecosystem services. More recently there has been increased interest in its value for trading markets. Extensive biodiversity monitoring has been carried out on Llara Farm, an 800 ha dryland cotton and grain farm in Narrabri. Visual surveys have identified 81 plant species (and rising) and 107 invertebrate species groups and 140 unique bird species. Digital technology has also been used to carry out surveys of mammals, birds and bats: 20 motion sensor mammal cameras have identified 55 terrestrial animal species; 20 bird eco-acoustic monitoring devices have identified 105 bird species and 20 bat audio monitoring devices have identified 14 species of bat including 5 threatened species. In addition to contributing to farm natural capital, these species are also important to productivity, and providing ecosystem services such as natural pest control (e.g., mice & insects). We have also used GPS collars on 15 feral pigs to provide valuable insights into how the local pig population spatially utilise the landscape throughout the year to allow better informed management decisions to be made.

Unravelling the components of mesophyll conductance in *Gossypium* species to improve tolerance to heat and drought stress.

Demi Sargent, Warren Conaty and Robert Sharwood
Western Sydney University, CSIRO

Cotton yields are predicted to decline with the increasing frequency and severity of heat and drought events due to climate change. However, improving photosynthetic efficiency and resilience to abiotic stresses are promising solutions to developing climate-adapted cotton germplasm. A poorly understood avenue of photosynthetic enhancement is improving the temperature sensitivity of mesophyll conductance. This process can be understood as the 'gatekeeper' to photosynthesis, controlling the entry of CO_2 inside the leaf, thereby regulating photosynthetic carbon assimilation and growth. New findings have uncovered native Australian cotton species with greater thermotolerance and higher propensity to facilitate the entry of CO_2 into the chloroplasts. However, the mechanisms behind variation in mesophyll conductance in cotton are unknown. Our research uncovers interspecies variation in the temperature sensitivity of mesophyll conductance and its response to a combination of heat and drought stress treatments. An update on this research will be presented.

An overview of Verticillium host range.

Linda Scheikowski, Linda Smith
Department of Agriculture and Fisheries, Queensland

The soilborne fungus causing Verticillium wilt, *Verticillium dahliae* Kleb, has a wide host range including weeds and economically important crops. New plant species continue to be reported succumbing to this disease worldwide. While field trials have highlighted the benefit of maize and sorghum in reducing soil inoculum levels compared to continuous cotton, glasshouse pathogenicity studies have revealed many other crops rotated with cotton have the potential to be infected. An overview of the status of alternate hosts of *V. dahliae* and possible implications for disease management will be examined.

Development and application of rapid molecular assays for cotton pathology.

Murray Sharman, Linda Smith
Department of Agriculture and Fisheries, Queensland

Several endemic cotton diseases cause yield and economic losses in many Australian cotton growing regions. Exotic diseases also present significant biosecurity risks. Traditional mycology methods can take days to weeks for a diagnosis and standard PCR methods for viral diseases can still take 1-2 days to complete. Rapid diagnostics such as new Loop-mediated isothermal amplification (LAMP) provide an opportunity to provide diagnostics within 1-2 hours from sampling symptomatic tissue. This can provide a significant time saving in the lab and greatly reduce turnaround time to advise affected growers, leading to better management outcomes.

We have targeted pathogens that are either emerging, pose a biosecurity threat or may be difficult to distinguish from other diseases by symptoms alone. We have developed LAMP assays for endemic diseases cotton bunchy top virus 1 and 2 (CBTV-1, -2), *Eutypella* sp., Fusarium Fov, and Ramularia pseudoglycines affecting cotton, We have also developed diagnostics for the exotic cotton leafroll dwarf virus (CLRDV) for incursion preparedness.

These LAMP assays are already proving useful for rapid turnaround diagnostics for CBT samples which increased in incidence in many areas in the 2022-23 season. We are beginning to apply the Eutypella LAMP to search for alternative hosts and pathogen reservoirs in the environment. The Ramularia LAMP was used to confirm infections in WA cotton, not reported in that region for several decades.

Opportunities for improving cotton production under future climates – the new role of synthetic biology.

Robert Sharwood, Demi Sargent, Garima Dubey and Warren Conaty.
Western Sydney University, CSIRO

The increase in anthropogenic CO¬2 emissions continues to threaten cotton production in Australia and worldwide through the increase in extreme weather events such as heatwaves and drought. These alarming climate trends will require new solutions to improve germplasm to be more efficient in the use of water and have an improved capacity to deal with heatwave conditions. Therefore, the goal of this research is to improve the capacity for germplasm to cope with periods of elevated temperatures and water deficit by improving photosynthetic carbon assimilation by targeted engineering of enzyme activity and thermotolerance properties. The advent of synthetic biology platforms to design new versions of enzymes with desired properties has made it possible to artificially induce variation into key photosynthetic proteins. With knowledge gained from variation in photosynthesis among Gossypium species, we can now inform new strategies to improve thermotolerance of carbon assimilation to mitigate climate extremes and ensure future fibre production.

Reoccurring wilt: The Eutypella story

Linda Smith, Dinesh Kafle, Linda Scheikowski and Gupta Vadakattu
Department of Agriculture and Fisheries, Queensland, CSIRO

Reoccurring wilt is a recently described lethal disease of cotton, first detected in Central Queensland in the 2017/18 season. Pathogen identification was established on sequences of the ITS region of rDNA, revealing the presence of two novel *Eutypella* species. In Qld, the disease has since been detected in St George, Darling Downs, and Border Rivers region. Sequencing of roots and rhizosphere soil from diseased field grown cotton and the adjacent soil, indicated that the pathogen dominated the root microbiome but was not present in the rhizosphere or surrounding soil. Spore traps were strategically placed in-field to determine the presence of Eutypella ascospores. The source of inoculum and transfer of pathogen will be discussed. This study expands current knowledge on epidemiology of *Eutypella* spp. and provides information for developing management strategies against Reoccurring wilt.

A study of cotton bunchy top, will it go viral?

Melanie Soliveres, Phil Hands, Gosia Pilat and Iain Wilson
CSIRO

Cotton bunchy top (CBT) disease is a significant threat to the Australian cotton industry. Symptoms include stunted plant growth, pale green angular patterns at the leaf margins and dark green centres with a leathery texture. The disease is spread by the cotton aphid and the causal agent is the cotton bunchy top virus (CBTV) belonging to the Polerovirus diseases. CBTV shares some sequence similarities with another Polerovirus disease; cotton blue disease (CBD) that is caused by the Cotton leafroll dwarf virus and although not present in Australia, is widespread in Asia, South America and has been found in East Timor.

Cotton resistance for both viruses, genetically map in the same region, and could possibly be the same. Traditionally disease resistance/susceptibility is assayed by feeding aphids on infected plants then transferred to healthy plants. However, this assay is complicated and inaccurate and is not good enough for resistance gene identification.

Following in the steps from a Brazilian study on CBD we have synthesized an artificial CBTV construct and transformed it into Agrobacterium, to try different methods of infections and see if we can reproduce a natural infection from the synthesized virus. So far two methods have been trialled: syringe infiltration the leaf and vacuum infiltration.

We discuss the effectiveness, reproducibility, and accuracy of each method and if these aphid-less methods can become a new way of assaying breeding material for CBT resistance.

From the Holocene epoch to the era of AI.

Warwick Stiller (*Plenary*)
CSIRO

Cotton has been grown, spun and woven into cloth for at least 5,000 years and by 1500 was generally known around the world. This presentation takes you on a journey to unravel the origin of cotton, drawing insights into its biology, potential, and limitations. We delve into the historical tapestry of cotton cultivation and its adaptation to diverse environments, shedding light on the crop's unique characteristics. By understanding its origins, we gain valuable perspectives on cotton's inherent traits and laying the foundation for unlocking its untapped potential. For hundreds of years, breeders have aimed to improve the crop and are recognised as the grand integrators who constantly balance the imperative for strategic research with the demands of commercial profitability and timelines. We explore the pivotal role breeders have played in shaping past, present, and future innovation. Ground-breaking technologies like artificial intelligence (AI) and gene editing have the potential to further revolutionise the field, opening new avenues for progress with data-driven insights that promise further optimization of breeding strategies and accelerated variety development. Applying these advancements in a practical context, we present a captivating case study that explores new frontiers in cotton breeding. While we celebrate the triumphs of cotton breeding, we also confront the sobering realities of intricate genome complexities and the challenges this provides when exposed to a high input managed farming system.

How to attract and retain young people to the cotton industry.

Amy Cosby, **Melissa Sullivan**, Nicole McDonald
Central Queensland University

To ensure the cotton industry can attract and retain a highly skilled workforce, it is vital the next generation are aware of the variety of opportunities, have a favourable perception and can connect their personal interests, strengths and values to a career in the sector. The 'How to attract and retain young people to the cotton industry' project will target secondary school and university students, in cotton growing and metropolitan regions across NSW and QLD. The aim is to engage a diverse cohort of young people to understand their perception of the cotton industry and expose them to interventions that support them to explore employment opportunities in the sector. The project will involve focus groups with university students enrolled in agriculture and related (e.g. business, science, environmental science) degrees. The focus groups will explore why students chose to study at university, what factors they consider when deciding to apply for a job within agriculture and the cotton industry in particular and their opinions on a range of tools and platforms commonly used to advertise roles. Preliminary results demonstrate potential barriers, especially around understanding research pathways that are critical for industry innovation, and unnecessary blockages created by agriculture jobs advertising. Facebook was found to be an important gateway social media strategy, but face-to-face engagement is critical to engaging the future agricultural workforce.

Insect pest management and research in U.S. cotton.

Sally Taylor and Ryan Kurtz
Cotton Incorporated

Forty-five years following initiation of the boll weevil eradication program and almost three decades following the introduction of transgenic cotton, insect pests still challenge cotton grown in the United States (U.S.). A complex of insect pests infests U.S. cotton from emergence to harvest, and the number and diversity of pest pressures varies across geographic regions. The mission of Cotton Incorporated's Agricultural and Environmental Research division is to help farmers increase yields, manage costs, and reduce their environmental footprint. This presentation briefly summarizes insect control needs across the U.S. cotton belt and highlights some of the basic and applied research programs that help to monitor and develop tools to manage these pests.

Predicting micronaire using variables from an industry agronomic database (ERICA)

Chris Teague, Michael Bange and the CSD Extension Team
Cotton Seed Distributors Ltd

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. Recent published research from detailed experiments has demonstrated improved ability to predict micronaire when variables that affect assimilate production and crop supply dynamics are included. This presentation outlines results from attempts to apply the same principles identified from detailed research applied to an industry database (CSD ERICA) attempting to predict end of season micronaire. When measures of crop size at flowering (total nodes), boll size at maturity, and average temperature for the boll filling phase were used to predict micronaire (for both rainfed and irrigated crops) the predictive ability was improved by over 10% over the existing industry model that includes only temperature during boll filling. These analyses can provide insights that can guide more refined modelling approaches (eg. machine learning) and identify which variables may be taken with remote and proximal sensing technologies to improve precision of predictions.

An approach to map cotton fibre quality on commercial farms using remote sensing and geostatistics.

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The University of Sydney

Cotton fibre quality is important for growers to attain premium prices, but the drivers of variation are often difficult to understand or predict. There is currently no sensor available to map cotton fibre quality on-the-go like quality variables of other crops (e.g. grain protein content). Instead, this has typically been presented as a module (areal) average that is not always linked to in-field locations. A generalised approach to downscale areal observations is illustrated using cotton yield and fibre quality (length and micronaire) data. Two features of the downscaling algorithm are: (i) to estimate spatial trends in yield and quality with fine resolution, publicly-available predictors such as remote sensing imagery, and (ii) use area-to-point kriging (A2PK) to downscale the observations or the residuals from the trend model from areal averages. Results show that spatial trends in yield and micronaire could be estimated using regression with remote sensing imagery, whereas A2PK was chosen as an alternate modelling approach for downscaling areal observations for length. Satellite imagery used in the final regression models was predominately from later in the growing season during reproductive growth stages. Fine-resolution maps of cotton fibre quality can help to improve our understanding of the drivers of variation (e.g. subsoil constraints and/or management) both within and between fields, or potential management options (e.g. module staging or blending).

Starving soil microbes: consequences to cotton plant and soil health.

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Soil biological health plays an important role in functions related to nutrition, health and productivity of Australian cotton crops. Surface soils in cotton growing regions are generally low in organic carbon levels hence C inputs from roots and crop residues are important sources of energy for soil biota. Effects of fallow as part of rotation in cotton systems on soil biological and chemical properties: microbial biomass (MB), microbial activity, diversity (genetic and catabolic) and disease suppression potential were investigated to determine consequences to plant and soil health in multi-year field experiments and farmer fields over multiple seasons. MB-C levels generally ranged between 100 - 600 µg C/g soil and >90% of cotton soils have microbial quotient values <5%, an attainable threshold for agricultural soils. Soils from the Fallow-Cotton rotation generally showed significantly lower MB (the 'engine' for all biological functions), abundances of total fungi and bacteria, specific groups of beneficial bacteria, microbial catabolic and genetic diversity of bacteria and fungi and pathogen suppression potential thereby weakening the biological buffer compared to that under other rotations including continuous Cotton. Overall, these results suggest that non-crop periods as part of cotton rotation system should be considered not only for their impacts on plant pathogens but also on MB and beneficial microbial communities to manage the health of cotton plants and soils.

Effect of nitrogen application rates on cotton yield and fibre quality- results from recent trials in Australia.

M.H.J van der Sluijs and T.B. Weaver
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A recent extensive review showed that the effect of nitrogen application rates on fibre quality were varied and inconsistent. As a consequence, trials were conducted in Australia in 2018 and 2019 in four locations using three popular high yielding commercial varieties sown in the Australian cotton industry. Nitrogen was applied in the form of granular urea in three locations, in split applications either before or in-crop with Anhydrous ammonia applied at the fourth location before planting. Application rates ranged from zero (0 kg.ha-1) to moderate (100 to 200 kg.ha-1) to high (300 kg.ha-1) and excessive (400 kg.ha-1).

The application of moderate (100 to 200 kg.ha-1) rates of nitrogen resulted in the highest yield and nitrogen use efficiency and produced the longest, uniform, and strongest fibre. As the growing conditions for the two seasons were ideal it was shown that nitrogen application rates did not influence micronaire but did negatively affect colour and lint turn out.
Nitrogen application rates do impact yield, lint turn out and fibre quality. However excessive application rates above 14 to 15 kg of N per bale had no economic benefit to the grower and could negatively affected yield and fibre quality.

Future Farm: Using a Shiny app and Google Earth to access satellite data to make better N decisions.

Tim Weaver, Peter Grace, Stephen Leo, Kellie Gordon
CSIRO

The CRDC - Future Farm project - investigated different sensor technologies (proximal-crop circle and remote-Sentinel 2) to capture crop vegetation indices from cotton and relate them to nitrogen in cotton crops. Relationships were built between the vegetation indices (NDRE) and the cotton N status. The relationships were then validated against five crop models to estimate the best prediction of N status in the cotton crop. The results were tabulated and RMSE compared to select the best predictive model. The final model chosen was the Nitrogen Fertiliser use optimisation model (NfUE). The model was built into the back end of a Shiny App. that equips growers or consultants to upload their cotton field as a kml, kmz or zip file, generated from Google Earth. The app. allows for the selection of non-cloudy days. In addition to the kml file the Shiny app requires the input of planting date, to assist with the generation of growth day degrees (Base 12), selection of irrigation type (Dryland, Sprinkler or Furrow) and the targeted NfUE (i.e. 13-18 kg lint/kg N). The user also needs to enter their estimated gin turnout (30-50%) and the total amount of N fertiliser already applied as well as the initial soil nitrate-N status. Once the map of the field and all the inputs are entered into the app, the user selects the 'Predicted ONR/Yield' function, and you are then able to view the predicted optimum nitrogen rate and lint in bales per hectare to achieve the targeted NfUE.

Utilising the double knock to increase efficacy of weed control on major weeds in Xtendflex cotton systems.

Jeff Werth, David Thornby, Michelle Keenan, James Hereward, and Bhagirath Singh Chauhan
Department of Agriculture and Fisheries, Queensland

Cotton with resistance to dicamba and glufosinate and glyphosate (XtendFlexTM) will be released this season. The addition of glufosinate and dicamba will result in two additional modes of action to be applied in crop. The double knock has proven successful in managing glyphosate resistant weeds in fallow. Substituting glufosinate for paraquat as the follow-up herbicide should be an effective way to increase weed efficacy and manage herbicide resistance.

In a glasshouse experiment, treatments containing glyphosate, dicamba and clethodim (grasses) and glyphosate mixtures with dicamba or clethodim were applied with follow-up glufosinate applied at 1, 3, 7 and 10 days later. These combinations were applied to glyphosate-resistant and -susceptible populations of *Conyza bonariensis*, *Sonchus oleraceus*, *Chloris virgata*, *Chloris truncata* and *Echinochloa colona*.

Total control of *C. bonariensis* was achieved with dicamba and glyphosate+dicamba followed by glufosinate at all timing intervals. Effective control of *S. oleraceus* was achieved with dicamba and glyphosate+dicamba fb glufosinate at all timing intervals. Control of *C. virgata* was achieved with glyphosate, clethodim or glyphosate+clethodim fb glufosinate 7 and 10 days later. Control of *C. truncata* was inconsistent, with the most effective treatment being glyphosate+clethodim fb glufosinate 10 days later. *E. colona* was controlled with all treatments apart from glyphosate alone on the glyphosate-resistant population.

Molecular biology to the rescue (again!): How genomics aids managing disease resistance in cotton.

Iain Wilson, Melanie Soliveres, Ray Yuan, Patrick Moody, Philippe Moncuquet, Zitong Li, Qian-Hao Zhu, Lucy Egan, Warwick Stiller
CSIRO

Cotton diseases are responsible for significant and widespread losses to cotton production in Australia. Host plant resistance represents an effective long term means to realise the true yield potential of our elite varieties. The complete DNA sequence of the genomes of all cultivated cotton species, in combination with low-cost sequencing technology, is changing the way disease resistance loci are identified and exploited in cotton. An update on the molecular progress on a number of important cotton diseases will be discussed, and how genomics era information and technology is accelerating our ability breed for increased host plant resistance.

Pollen based cotton transformation, is it possible?

Qian-Hao Zhu and Iain Wilson
CSIRO

Genetically engineered (GM) cotton is still difficult to achieve, as only a few old varieties are transformable. Integrating a gene of interest into cotton involves transforming one of these old lines and then crossing it into an elite commercial GM cotton variety, which can take a long time. Developing a variety independent transformation method that includes elite commercial cotton varieties, will be a game changer for deploying new traits in cotton production and for gene editing.

Recently there have been developments in nano technology, providing an opportunity for transforming pollen by using nanoparticles as gene carriers. A proof-of-concept experiment has been carried out, which demonstrated that magnetic nanoparticles coated with DNA can be absorbed by cotton pollens through their apertures in the presence of a magnetic field, and that transgenic seeds can be directly generated by pollination. This presentation will report the details of the experiments, and the results achieved, and the challenges for deploying the approach in cotton genetic transformation.

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