Department of Primary Industries

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COTTON PRODUCTION IN NORTH-WEST NSW: CLIMATE CHANGE MITIGATION OPTIONS

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OBJECTIVE

High yields associated with Australian cotton production minimise greenhouse gas emissions intensity. However, the industry as a whole continues to face pressure to demonstrate environmental credentials, especially given market pressure from synthetic fibres and developing nations. To respond to this pressure, we estimated the climate change impact of cotton production in North-West New South Wales, using Life Cycle Assessment (LCA) and tested the effect of an array of mitigation options.

METHODS

We conducted the study in SimaPro LCA software for the 2011-2014 production years, drawing on published data, survey data, scientific literature; and Australian and international databases. We assumed that 96% of production was from irrigated systems, with 85% of irrigation water pumped by diesel-powered irrigation pumps; and assumed a median yield of 10.28 bales per ha. We applied emissions formulae and factors from the Australian National Inventory Report, except where more specific published literature was available, particularly for fertiliser-related N_2O emissions and emissions from the decomposition of cotton residues.

RESULTS

We calculated the climate change impact on a cradle-to-port basis as 1601 kg CO_2-e per tonne of cotton lint, with 26% of emissions occurring during the pre-farm stage, 48% during the on-farm stage and 26% post-farm. Production and use of nitrogenous fertiliser contributed approx. 4% of the emissions.

RESULTS CONT'D

Several management scenarios were shown to reduce emissions intensity, including: optimising nitrogen application rate (2.6% to 13.2% reduction, for N=240 and N=180), use of controlled-release and stabilised N fertilisers (5.9%), solar-powered irrigation pumps (8.1%), biofuel-powered farm machinery (3.4%), legume crop rotations (3.9%) and fertigation (2.1% to 12.5%).

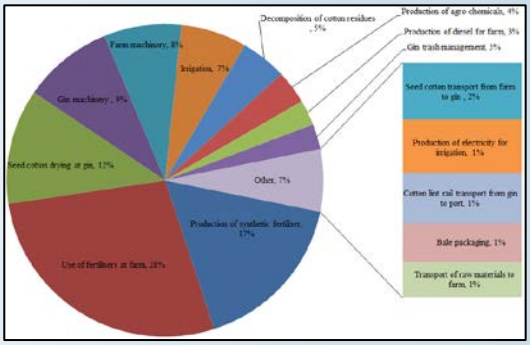

Figure 1. The relative contribution of different processes in the life cycle climate change impact.

CONCLUSION

We provide guidance about potential emissions reduction opportunities for incorporation into extension material and a platform to underpin ongoing analysis. Further research is required to understand the full life cycle consequences of biodiesel production, including alternative uses of the biomass and displacement of other land uses. From a legume break crop perspective, there is a need to better understand the potential reduction in carbon sequestration due to inclusion of a lower biomass crop in rotation.

[Source: NSW DPI Image Library]

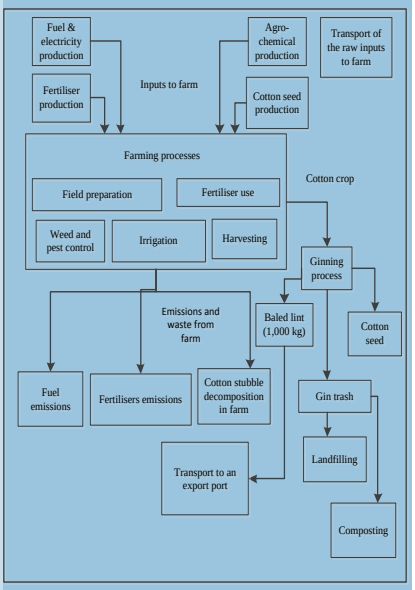

Figure 2. System boundaries

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MORE INFORMATION

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Cotton surface modification and functionalisation

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*The research provider RMIT acknowledges the financial assistance of the Cotton Research and Development Corporation in order to undertake this **Exploring nanofibrous coating on cotton fabric with versatile protection and dynamic comfort** project*

This study used visual representation techniques to explore relationships between cotton fibre properties and current approaches for modification and functionalisation of the cotton surface. The literature on relevant topics was reviewed to establish the conceptual framework, and the information was organised thematically and hierarchically. Mapping techniques were then applied to convert the information into a visual form.

Intrinsic properties of cotton make it one of the most used textile fibres. This popularity is greatly driven by consumers' demand for comfortable, easy care and safe products. Extensive research work has been done to develop approaches that add desired functionalities and improve aesthetics of cotton textiles. Finishes that provide functionalisation such as wrinkle resistance, flame retardancy, improve colour fastness and dimensional stability, impart soil, water and oil repellency, and reduce mechanical, bio and light degradation are common. However, the benefits provided by these approaches are often limited by their undesirable effects on cotton fibre. Manufacturing, use and recycling of cotton products have also raised some environmental concerns. These concerns led to legislative changes, requiring sustainable, more integrated processes capable of delivering high added-value textile and apparel products.

Additionally, the emerging technologies and continuous progress in new advanced textile materials present strong competition. Increased publics awareness and preferences for performance textiles are contributing to the growth of the clothing sectors like outdoor and sports, protective and work wear. For cotton to retain its place in global textile and apparel markets, technological advancement and further innovation in cotton modification and functionalisation methods are needed. Such new approaches would provide critical differentiation of the product, adding desired properties and value.

Anti Microbial

Microorganisms can cause degradation of cotton textiles, discolouration, unpleasant odours and may cause allergies and other health issues.

Medical textiles also may require biocidal function.

UV Blocking

Health risks from prolonged sun exposure.
Degradation of textiles due to UV radiation.

Flame Retardancy

Cellulose is a source of hydrocarbons and easily combusts.

Flame retardant fabrics are used as protective clothing for firefighters, military, police, and workwear, and for high performance sports, upholstery and transportation, sleepwear for children and elderly.

Water/Oil Repellency

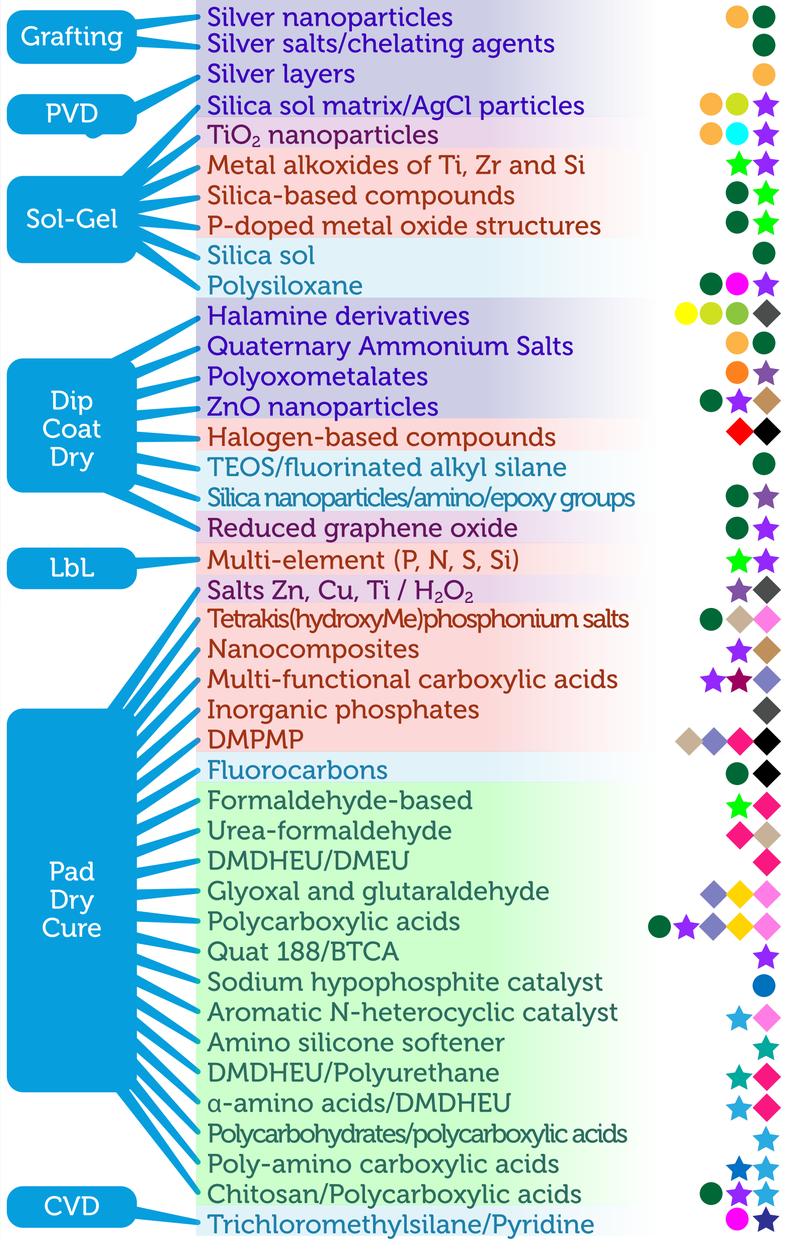
Repellency of water and other liquids provides self-cleaning function and extend the lifetime of the fabrics due to the prevention of degradation facilitated by damp textile.

Oil repellency in industrial or household textiles facilitates cleaning.

Wrinkle Resistance

Cotton fabrics are easily wrinkled during use and care. Absorbed during washing water allows movement of molecular cellulose chains in non-crystalline regions. The hydrogen bonding between re-arranged molecules then fixes the wrinkles in a drying fabric. Cross-linking agents limit the chains movement.

However, the finish often causes the loss of flexibility and reduction of tensile strength.



Advantages

- Anti-odour
- Biocidal
- Not inducing microbes resistance
- Slow-release mechanism
- Effect is rechargeable
- Self-cleaning on UV/light exposure
- Durability to laundering
- Durability to abrasion
- Retention of hand and softness
- Retention of strength
- Retention of whiteness
- Thermostability
- Thermo-insulating / char-forming
- Economical
- Potential additional functionality
- Reduction in pollutants

Adverse effects on properties

- Reduction in hand and softness
- Low durability to laundering
- Reduction in fabric strength
- Yellowing and discolouration

Processing issues

- Nanoparticles processing issues
- Cost/Patented process

Environment/health issues

- Formaldehyde
- Toxic combustion products
- Pollution, bio-accumulation

HOW TO CONTROL WEEDS IN COTTON?

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Introduction

Cotton (*Gossypium hirsutum L.*) is the most important commercial and fibre crop in the global market, covering an area of 2.5% of the world's arable land in over 100 countries. Weed are one of the most important biological constraints to the successful crop production and cause an estimated annual loss of $ 2.5 to $4.5 billion to Australian agriculture. Yield loss in cotton is in the range of 10-90% with an estimated opportunity production loss and on farm expenses of $173 million. Weeds can badly affect the growth, development, and yield of cotton crop by competing for space, light, water, and nutrients. Genetic modifications in crops have brought a significant revolution in the cotton industry and completely changed the weed management program to sole reliance on glyphosate. Such overuse of glyphosate has resulted in the evolution and development of glyphosate resistant (GR) weed populations. Currently, 37 GR weed species are recognized worldwide and this number is increasing on a daily basis. The present study is designed to address this burning issue.

Materials and Methods

The present study was carried out at the Gatton farm of the University of Queensland to evaluate the effects of different herbicides on weed control of GR cotton cultivar Roundup Ready 75 RRF during summer season of 2015–16 and 2016-17. Soil was a heavy loam with a pH of 7.48 and an organic matter content of 2.8 percent. The experiment was arranged in a randomised complete block design with three replications. Different treatments are given in Table. Irrigation was applied through a sprinkler system. First irrigation was applied right after planting and subsequent irrigations were adjusted according to the needs of the crop. Insects were controlled by using recommended insecticides. Weed density, weed biomass and seed cotton yield were recorded.

Table 1: Herbicides rates and timings used in the experiment

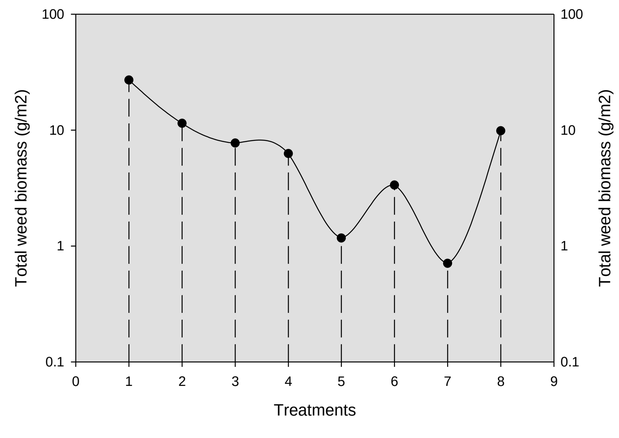
Herbicides	Trade names	Formulation	Application rate	Time of application
Glyphosate	Weedmaster DST	470 g ai L^{-1}	1034 g ai ha^{-1}	Post-emergent at 20 and 35 DAS
S-Metolachlor	Bouncer 960S	960 g ai L^{-1}	960 g ai ha^{-1}	Pre-emergent soil application
Pendimethalin	Rifle 440	440 g ai L^{-1}	1496 g ai ha^{-1}	Pre-emergent soil application
Haloxyfop	Verdict™ 520	520 g ai L^{-1}	78 g ai ha^{-1}	Post emergent at 20 DAS

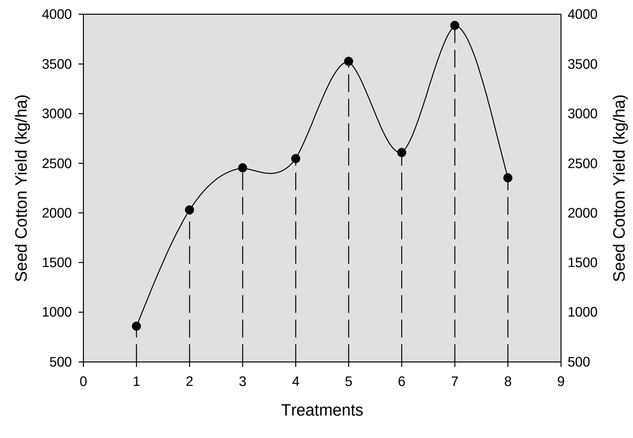
Table 2: Herbicides treatments

1	Weedy (Control)
2	Glyphosate applied once
3	Glyphosate applied twice
4	Glyphosate + metolachlor
5	Metolachlor
6	Glyphosate + pendimethalin
7	Pendimethalin
8	Glyphosate + haloxyfop

Results

Pre-emergence application of pendimethalin and metolachlor proved very effective in controlling all types of weeds and provided total weed biomass reduction of 97 and 96%, respectively, over control whereas glyphosate applied once and twice recorded weed biomass reduction of 58% and 71%, respectively and did not show any significant effect on the reduction of *Chloris virgata*. Seed cotton yield was also observed higher for pendimethalin and metolachlor. Pendimethalin and metolachlor treatments recorded an increase in seed cotton yield of 353 and 311%, respectively over the weedy control as compared to glyphosate applied once and twice (136 and 186%, respectively).





Weedy (control) treatment

Pendimethalin treatment

Conclusions

Results concluded that the pre-emergence application of pendimethalin and metolachlor provided more weed suppression throughout the growing season due to its residual soil effects. This was translated into more vigorous crop growth and development and ultimately higher cotton yields. In comparison, post-emergent applications of glyphosate either alone or in combination with other herbicides did not provide effective weed control and resulted in lower seed cotton yields. Glyphosate also showed poor efficacy on *Chloris virgata*.

Keeping in view these results, pre-emergence herbicides like pendimethalin and metolachlor should be included in the weed management program of glyphosate-tolerant cotton. In this way, pressure on the single reliance of glyphosate will decrease, which will help to slow the evolution of new glyphosate resistant populations.

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Acknowledgements

Support of UQ-Gatton Farm Team is highly appreciated.

Effect of cotton residues on N_2O emissions and soil N following incorporation

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Background

- Nitrous oxide (N_2O) is a greenhouse gas 298 times more potent than carbon dioxide (CO_2) [2]
- Incorporation of crop residues known to increase N_2O and CO_2 emissions, and soil nitrogen (N) content
- Emission factors (EFs) (% of residue N lost as N_2O) vital for estimating N_2O budgets and mitigation strategy development. Current default IPCC EF = 1% [2]
- No data exists on cotton residue-induced N_2O emissions and its N contribution for subsequent crop

Project Aims

- Quantify CO_2 and N_2O fluxes, and corresponding EFs from a cotton fallow in sub-tropical Australia
- Determine cotton residue contribution to soil N available for subsequent crop

Experimental set-up at Oakey, Queensland

Materials and Methods

- Field site set up in Oakey, Queensland during 2016 cotton fallow period
- 4 treatments: control (C), C + 50mm rainfall monthly (C+I), residue retention (R), and residue retention + 50mm rainfall monthly (R+I). Residues contained 77±3.5kg N/ha
- Semi-automated greenhouse gas chamber system measured CO_2 and N_2O every 2 days
- Plant available N (NO_3^- and NH_4^+) in the topsoil (0-10cm) measured periodically
- Isotope ratio mass spectrometry (IRMS) to determine N contribution and losses from ^{15}N labelled cotton residues

Semi-automated greenhouse gas chamber

Results and Discussion

- Cumulative N_2O emissions ranged from 20.5 to 63.7g N/ha (table 1) with R+I resulting in the highest N_2O emissions followed by R, C then C+I. These values are at the lower end of other reported cotton fallow periods with residue removal and incorporation [3-5]
- The comparatively low N_2O emissions compared to other post-harvest phases reported in the literature might be due to the high C:N ratio of cotton (30:1), the low concentration of easily decomposable carbon from the residues, and the alkaline soil pH (7.8) [1]
- Emission factors for the cotton fallow period were 0.015% and 0.051% for R and R+I, respectively (table 1)
- Soil respiration (CO_2) was significantly higher in the R+I treatment following incorporation (fig. 1)
- Cotton residue incorporation resulted in immobilisation of N (consumption of inorganic N by soil microbes to assist with carbon decomposition) particularly in the NH_4^+ pool (fig. 2)
- The majority of residue N in both R and R+I treatments was recovered in the top 20cm of soil at the end of the fallow

Table 1: Cumulative CO_2 and N_2O emissions, and corresponding EFs. Different letters correspond to significant differences ($p < 0.05$).

Treatment	CO_2 emissions (kg CO_2-C ha^{-1})	N_2O emissions (g N_2O-N ha^{-1})	EF (%)
C	381.6 ± 52.6^a	24.5 ± 5.7^a	-
C+I	485.7 ± 34.8^a	20.5 ± 1.4^a	-
R	435.4 ± 40^a	35.1 ± 4.1^a	0.015
R+I	800.3 ± 36.8^b	63.7 ± 18.9^a	0.051

Figure 1: Soil N_2O (top) and CO_2 (bottom) fluxes for all four treatments over the cotton fallow period

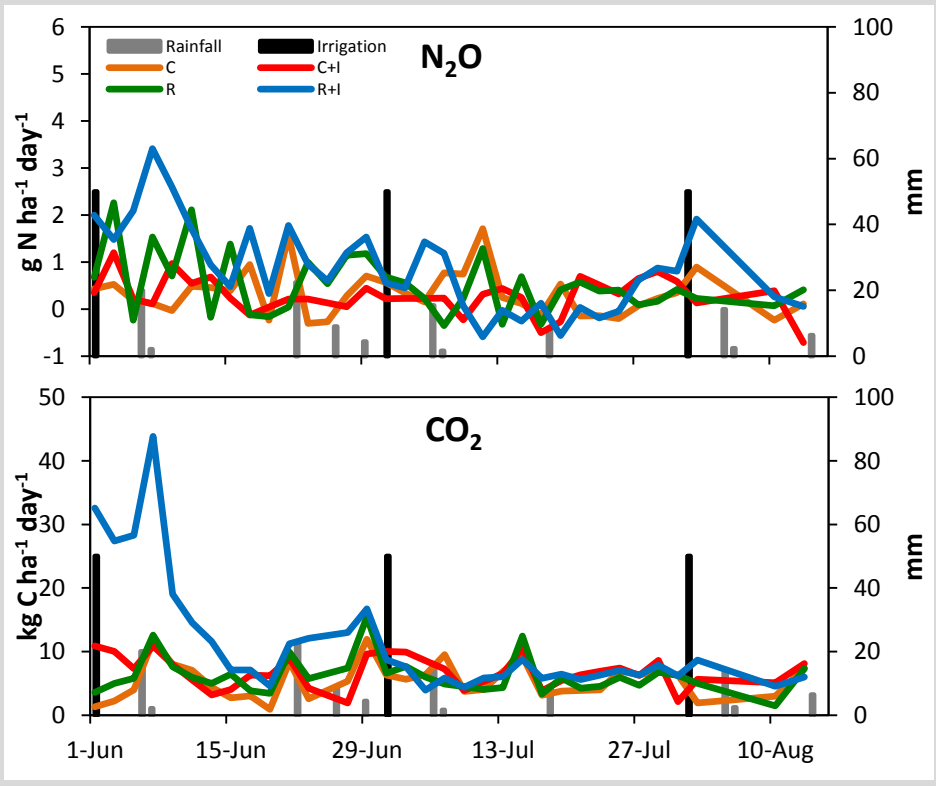
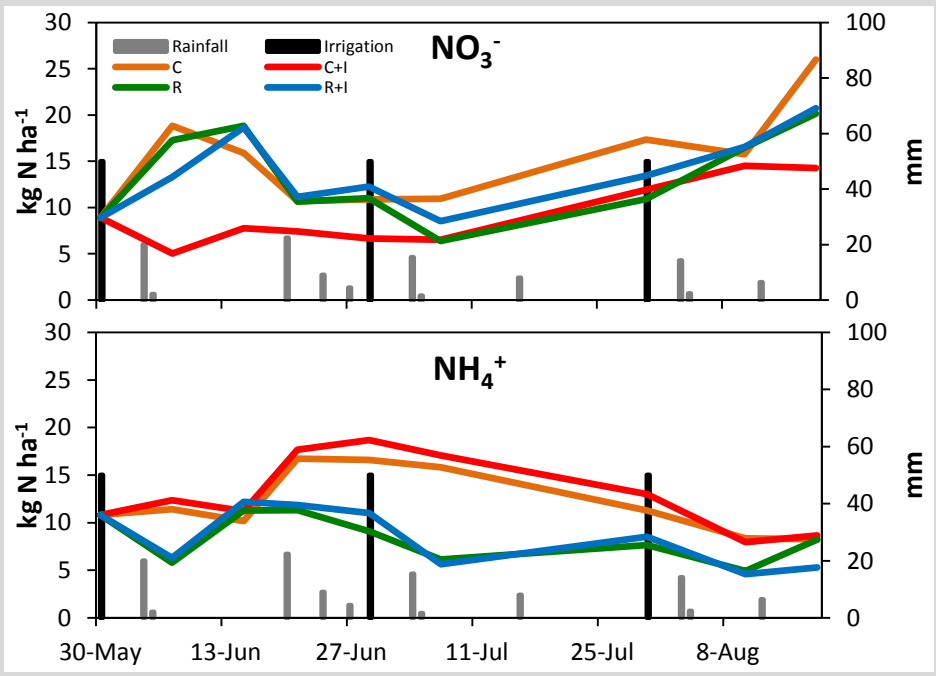


Figure 2: Plant available N, NH_4^+ (top) and NO_3^- (bottom), for all four treatments over the cotton fallow period



Conclusion

- N_2O emissions from cotton residues are minimal and the IPCC default EF of 1% needs to be re-evaluated
- Cotton residue incorporation contributed mostly to topsoil N while a very minimal amount was lost
- Cotton residue N contribution and immobilisation needs to be considered in the N fertiliser applications

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EXPLORING MODES OF ACTION OF NOVEL BIOPESTICIDES: FROM MODEL CELL LINE TO TARGET INSECTS

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INTRODUCTION

This study utilizes a suite of cross-disciplinary methods to elucidate the mode of action of highly active, novel insecticidal plant extracts. These include bioassays at the whole organism and cellular level, fluorescence microscopy to measure associated biochemical stress responses, electrophysiology to elucidate ion flux and channel behaviour, and finally relating these measurements to gene expression by transcriptomic analysis. Initial bioassays using cotton bollworm (*Helicoverpa armigera*), cotton aphid (*Aphis gossypii*) and two-spotted spider mite (*Tetranychus urticae*) identified three novel extracts with insecticidal potential.

The main research questions we to aim to answer are:

1. Does a correlation exist between the insecticidal effects at the whole organism level and those at the cellular level?
2. What is the target site(s) and how does the candidate compound affect the target site(s)?
3. Does the candidate compound affect genetic regulation in the target organism?

METHODS AND MATERIALS

Drosophila melanogaster (*D.mel*-S2) cells were challenged with 13 extracts at final concentrations of 0.01% w/v with two known insecticides as positive controls, pyrethrum and W11N, and the background diluent DMSO as a negative control. Growth inhibition was measured using absorbance spectrometry (OD600), kinetically for 4 hours, then mortality was counted at the endpoint using a haemocytometer.

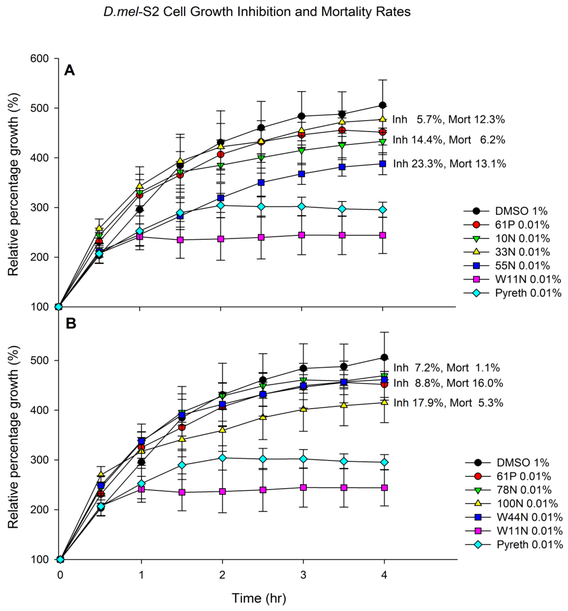
Wild type ferment fly (*D. melanogaster)* adults, isolated soon after emergence, were subsequently separated into mated females and virgins (for later RNA sequencing). Whole organism bioassay was performed using extract 68N at dilutions between 2.0% and 0.0625% w/v, delivered via a Potter precision spray tower onto flies and gravid cotton aphids.

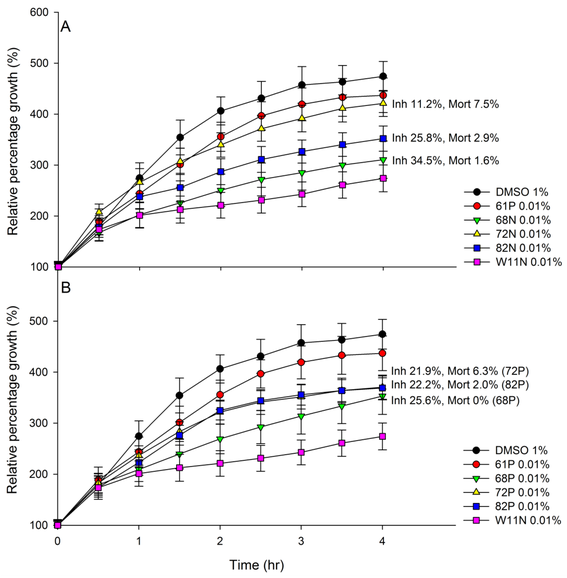
Reactive Oxygen Species (ROS) was measured by confocal fluorescence microscopy of *D.mel*-S2 cells using a selection of extracts. Cells were dyed with 2',7'-dichlorodihydrofluorescein diacetate.

Electrophysiology studies measured the net K^+, Na^+ and Cl^- ion flux of a population of cells and compared the three most potent extracts against positive and negative controls.

RESULTS

Absorbance spectrometry results from 13 extracts showed that 68N was the most effective extract causing the greatest inhibition of cell growth, followed by 82N. Whole organism bioassay results showed that extract 68N did not kill adult flies or bees, presumable due to cuticle barriers, although mortality of cotton aphids was rapid even at low concentrations.





Figures 1 (A&B) & 2 (A&B). Results are shown as the relative growth percentage to starting concentration (n=3 plates, totalling 15 wells per treatment). Negative control (DMSO 1%), positive controls, pyrethrum and extract W11N, treatments extract #10N, #33N, #W44N, #55N, #61P, #68P, #68N, #72P, #72N, #78N, #82P, #82N, #100N. The average seeding rate was 0.5 million cells per ml at a viability rate of at least 95.0%. Each plotted value is the mean ± SE (n=15).

Fluorescence microscopy results validate the use of reactive oxygen species as an early stress indicator. Each extract showed a distinct pattern of response with a clear distinction in post-treatment ROS production when compared to a fairly steady ROS production within untreated cells.

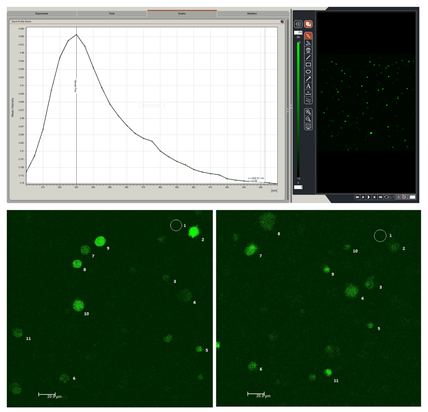


Image 1 & 2. Confocal images before and after extract treatment of 10N at 0.1% w/v.

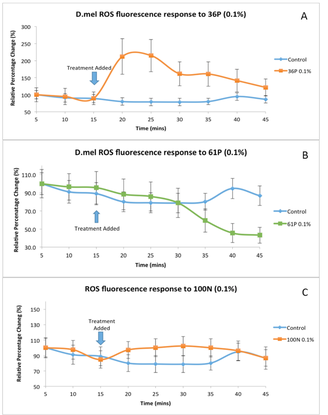
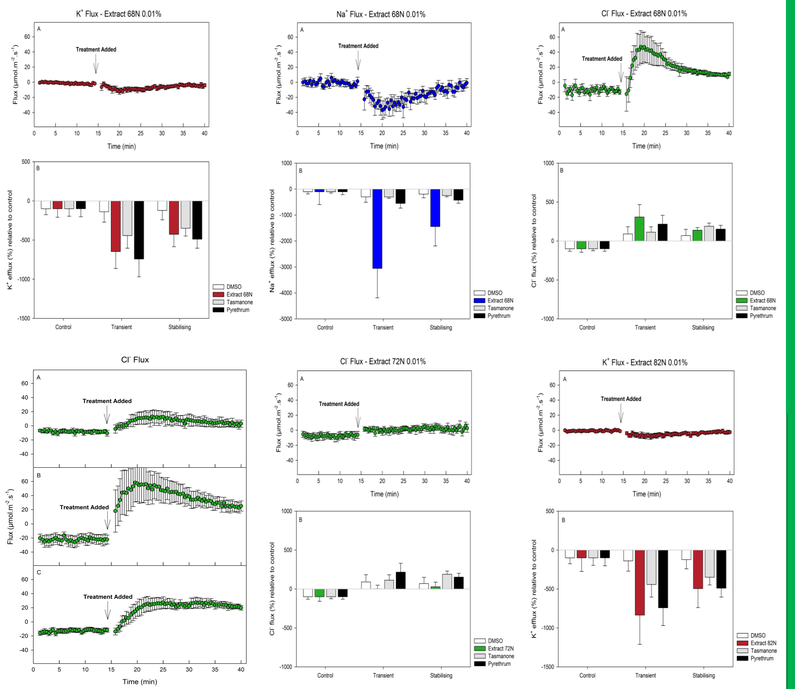


Figure 3. Relative percentage of change in ROS fluorescence

Electrophysiology results showed extract 68N elicited dual activity of both potassium and sodium efflux. All extracts caused an immediate reversal of chloride flux from steady efflux under control conditions to rapid influx once the treatment was added. Extract 72N suppressed the extremity of chloride influx suggesting a Cl^- channel blocking effect. Extract 82N caused greater potassium efflux than any other extract; and of a similar level to pyrethrum.



Figures 4-9. The MIFE trace of ion flux changes of the extract tested is provided to show the magnitude and real-time response curve. Then, the bar graphs for each extract are given for a direct comparison to both the negative and positive controls as a percentage of the flux relative its respective control, showing both immediate transient (first approx.10 mins) and stabilizing (next approx. 20 mins) response to each treatment

DISCUSSION

Most insecticides are nerve poisons that cause prolonged toxicant effects due to poor detoxification mechanisms in the nervous system. However, impacts on metabolic pathways as secondary sites must also be considered[1].

Pest resistance to many insecticides including pyrethroids via mechanisms associated with increased metabolism and detoxification are also commonplace, therefore new chemistries must be assessed for enzymatic response before being considered as a viable new option.

Findings to date indicate that two compounds, 68N and 72N, may have ion channel-related modes of action while 82N may employ non-neuronal toxicity. Whilst some other extracts showed toxicity to at least one cotton pest, the above three extracts show potential to become valuable tools in cotton IPM programs, targeting multiple pests without harming non-target species.

CONCLUSIONS & FUTURE WORK

In light of increasing insecticide resistance, there is a continuing need for new types of insecticides. Furthermore, in discovering novel chemistries that are neuroactive and/or act on non-nerve targets, we can increase insecticide diversity, which will help to maintain pest management strategies[2].

Future work will include elucidating the target site(s) of novel compounds, assessing their potential detoxification and resistance potential via enzymatic assays; superoxide dismutase (SOD), glutathione s-transferase (GST) and cytochrome P450 monooxygenases (CYP450)[3]. RNA sequencing will be employed to compare the differences in gene expression post-treatment in the model species and cotton pests in relation to rapid knock-down and insecticide-resistance genes .

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Optimising poultry litter management in cotton production

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Abstract
A field trial in Griffith NSW, examined the rate and placement strategy (banded or incorporated) of poultry litter and inorganic fertiliser at equivalent N rates on cotton plant growth, lint yield and quality, soil available N and biology.

Results
Crop N uptake

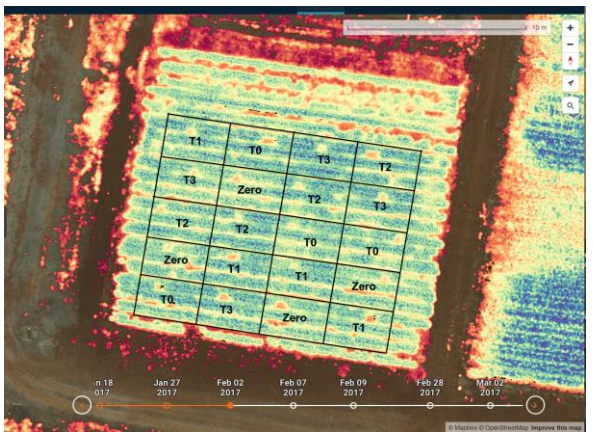

Figure 1. NDRE field map at 90 days after treatment application.
Significant difference between treatment NDRE means coincided with first flower and cut out (days after treatment application; 89*, 97*, 117*** and 125**).
Significance: *p≤0.1; **p≤0.05; ***p≤0.01.

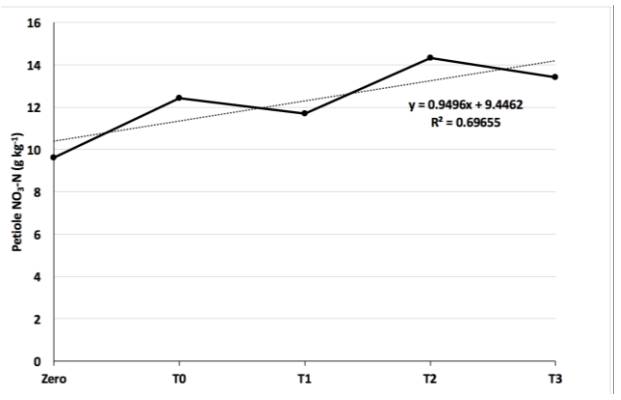

Figure 2. Relationship between petiole NO_3-N concentrations averaged over 645, 890 and 1102 degree days (DD) and applied-N.
Petiole NO_3-N concentration, ranging from 9.6 to 14.3 g kg-1, indicated soil N availability did not vary widely between treatments. Significant treatment difference between petiole NO_3-N means occurred at 645*, 890*** and 1102*** DD.

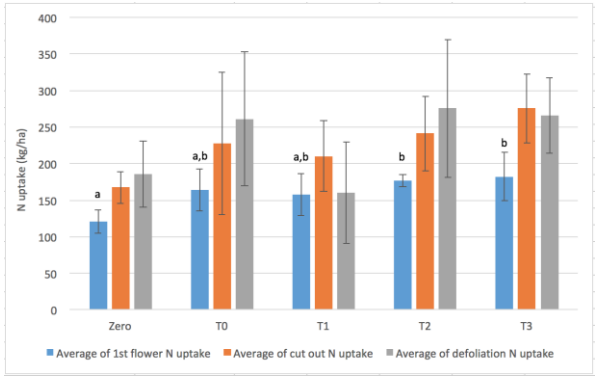

*Figure 3. Differences in crop N uptake at first flower**, cut out* and defoliation* with standard deviation bars.*
Letters between columns of the same colour are significant differences at p≤0.05.

Methodology
The trial was conducted on a Chromosol (loam), in a complete randomized block design with 5 treatments replicated 4 times. The treatments comprised a zero N control, farmer practice at 150 kg urea-N/ha applied by machine drill, and three poultry litter treatments applied manually using local non-composted fresh broiler litter.
Zero: Control, no N
T0: 150 kg urea-N/ha
T1: ~ 8t/ha dry litter weight broadcast and incorporated, providing an equivalent amount of available N as the T0 urea-N
T2: ~ 8t/ha dry litter weight banded into a 15 cm deep central trench and covered.
T3: ~16 t/ha dry litter weight broadcast and incorporated providing double the amount of available N compared with the T0 urea-N

Soil quality

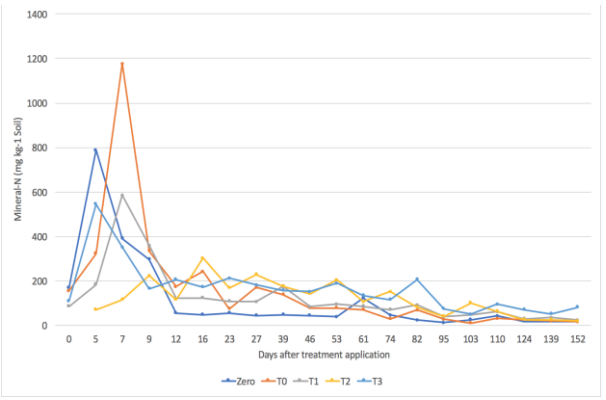

Figure 6. Net available soil mineral N over the growing season in response to treatments.
NDRE analysis and significant difference in treatment means indicates treatments Zero, T0 and T1 may be drawing on soil N reserves, particularly between days 74-152 after application.

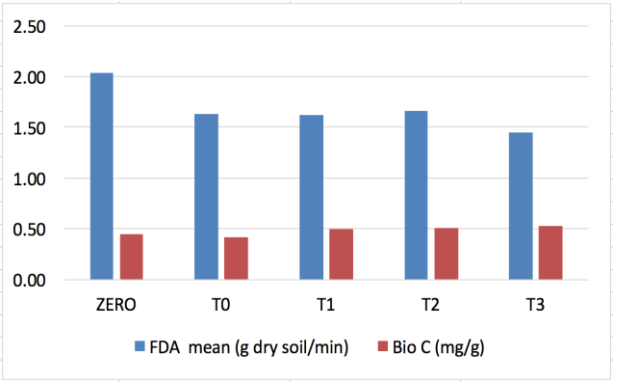

Figure 7. Fluorescein Diacetate Activity (FDA) and Biomass Carbon (Bio C) soil biology tests were conducted on 0-15cm soil at harvest.
The FDA tests show whether the microbes are active or not while the Biomass Carbon test is a measure of the weight of carbon present in the soil microbes. The FDA test for microbe activity found the Zero treatment had higher levels of activity compared with urea and litter treatments, however, the Zero treatment had low Bio C.

Lint yield and quality

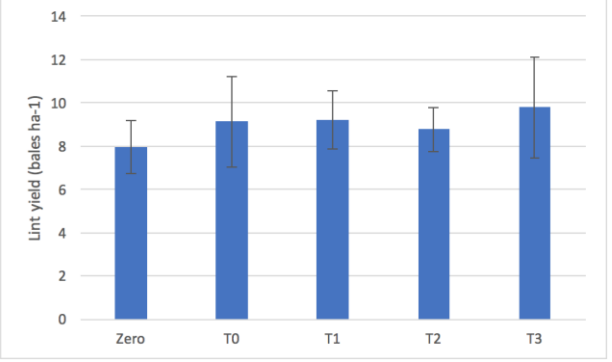

Figure 4. Average lint yield for treatments with standard deviation bars.
No significant difference between treatment means.

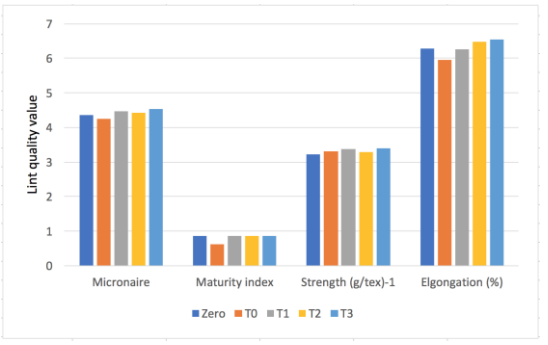

Figure 5. Lint quality of treatments for micronaire, maturity index, strength and elongation.
Analysis of lint quality parameters revealed that the Zero and T0 treatments performed poorly in micronaire, maturity, strength and elongation, while T3 generally had better quality. However, there was no significant difference between treatment means.

Discussion and conclusion
The Zero, T0 and T1 treatments had the lowest values of petiole NO3-N, crop N uptake (at first flower, cut out and defoliation), and NDRE from first flower until defoliation. The T2 and T3 treatments consistently remained at the upper end of each of these parameters, achieving greater plant N uptake and NDRE. Treatment effects on lint and soil biology were unclear.

In this first-year study the soil was relatively non-responsive to poultry litter due to initial high nutrient soil concentration and possibly different N leaching in treatments due to the free draining loam nature of the soil. Repeating the research in subsequent years is required to further examine treatment effects on yield, lint quality, soil biology and nutrient use efficiency.

Acknowledgements
Griffith CeRRF team: John Hornbuckle, James Brinkhoff, Carlos Ballester-Lurbe and Oliver Delves

Swelling of Cotton Fibers by Amino acid

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Introduction

In cotton industry, the swelling of cotton fibres has captured attention because of its importance in textile processes such as dyeing, cross-linking and most importantly mercerisation.

Swelling of the cotton fibers by mercerisation treatment is well known. However, this treatment requires highly concentrated sodium hydroxide solution which is corrosive. A similar improvement by a noncorrosive chemical treatment is therefore important for the cotton industry in this 'green-era'.

In this view, this project focuses on developing a user-friendly, nonhazardous, biocompatible method to swell the cotton fibers in order to modify properties.

In cotton, there are hydrogen bonds (as shown in figure 1) and this hydrogen bond network can be rearranged using amino acids as studied in this project. This rearrangement and further the new bond formation will lead to the swelling of the fibre.

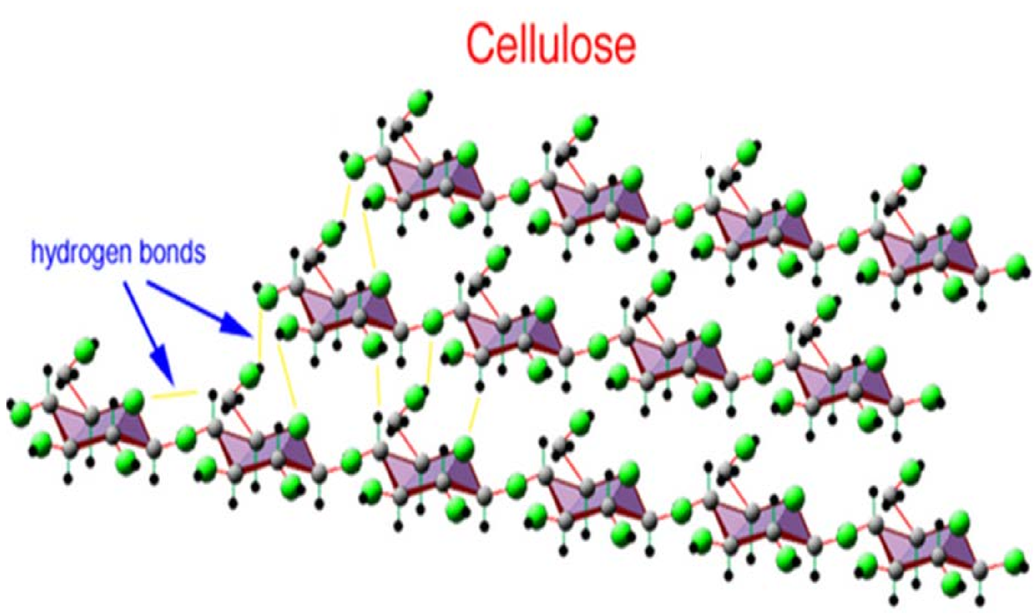


Figure 1: Hydrogen bonding in cotton cellulose

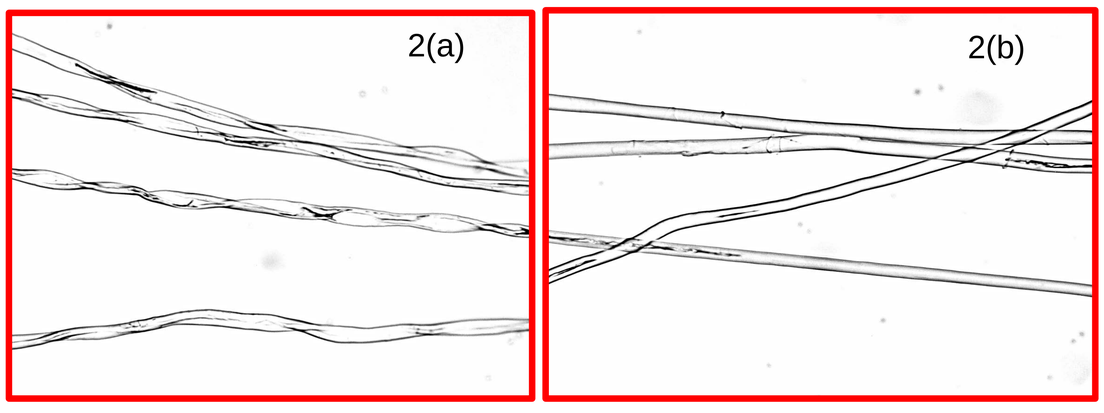
Goal: This project seeks to develop a non-hazardous and non-corrosive swelling method to improve the properties of cotton fibres

Objectives

- **To develop an user-friendly swelling treatment for cotton**
- **To study the effect of treatment on the properties of cotton fibres**

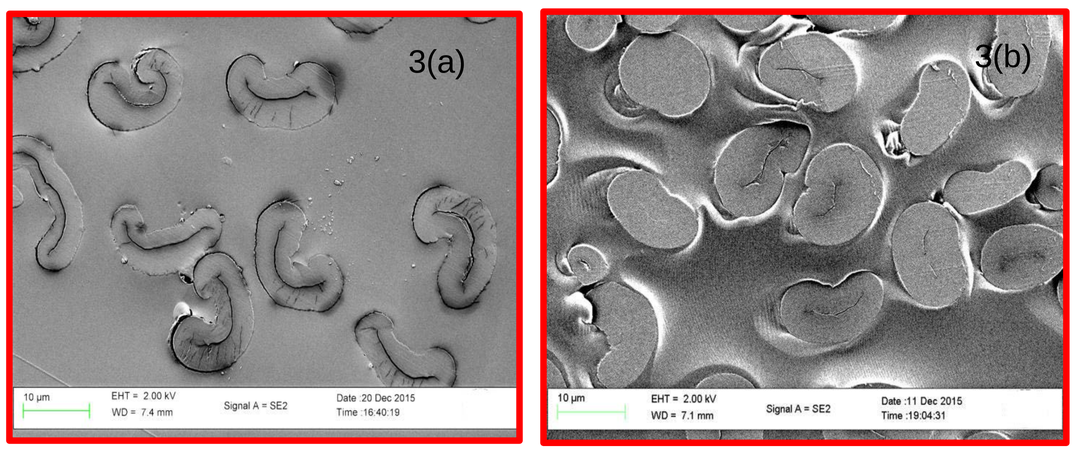
Results

From the optical images (figure 2) it can be observed that after glycine treatment the fibers were turned into more rod-like cylinders and the convolutions were completely removed. This is in agreement with the reported morphological studies of mercerised cotton fibres.



Figures 2(a) – (b): Optical microscopic images (x10) of scoured (a) and amino acid treated (b) cotton fibres

The cross-sectional shape of amino acid treated fibres have changed to more round in shape (Figure 3b)



Figures 3(a)-(b). Scanning Electron Micrographs (SEM) of scoured and amino acid treated cotton fibres cross sections

Table 1: Single fibre tensile test results (n = 200) and Moisture regain(%) of scoured and amino acid treated cotton fibres

Samples	Linear density(Tex) by cottonscope	Load (N) ± S.D	Specific stress (N/Tex) ± S.D	Strain (%) ± S.D	Moisture regain (%) ± S.D
Scoured cotton Control	0.198 ± 0.003	0.037 ± 0.010	0.194 ± 0.070	9.75 ± 2.900	6.63±0.500
Amino acid treated cotton	0.210 ± 0.019	0.045 ± 0.010	0.215 ± 0.060	15.48 ± 4.500	7.68±0.200

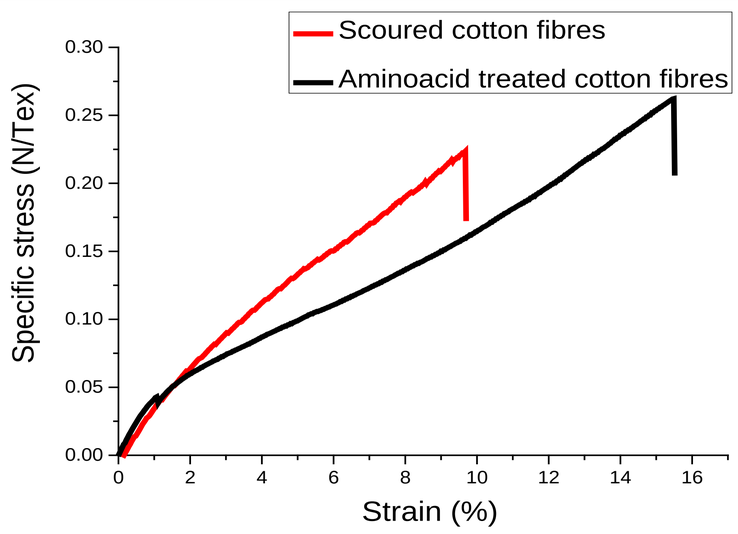


Figure 4: Specific stress- strain curve of scoured and amino acid treated cotton fibres

Conclusions

The amino acid treatment has:

- ✓ **removed convolutions of the cotton fibres**
- ✓ **changed the cross sectional shape of the cotton fibres.**
- ✓ **improved the tensile strength and elongation of the cotton fibres.**
- ✓ **Increased the moisture absorption of cotton fibres.**

References

- **Remadevi, R., Gordon, S., Wang, X. and Rajkhowa, R.,** 2017. Tensile, physical, and microstructure properties of glycine treated cotton fibers. *Textile Research Journal*, p.0040517517700196.
- **Remadevi, R., Gordon, S., Wang, X. and Rajkhowa, R.**, 2016. Investigation of the swelling of cotton fibers using aqueous glycine solutions. *Textile Research Journal*, p.0040517516665267

Acknowledgments

Australian Government
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Utilising plant growth regulators to develop resilient future cotton systems.

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Introduction.

Australian cotton is grown over a wide range of climatic and soil conditions, under both irrigated and rainfed regimes. Leveraging limited water resources for maximum lint production and optimal quality is of particular relevance to these (Australian) production systems, where the sustainable use of irrigation water has economic, environmental and increasingly social-licence imperatives; these pressures being expected to escalate with predicted climate change. Consequently, an industry imperative exists around the expansion of rainfed cotton production as a mechanism of both growing total production areas / volumes and existing industry adaption to increasingly variable climatic conditions.

Currently, synthetic plant growth regulators (PGRs) are utilised widely in Australian cotton production for control of excessive vegetative growth and to facilitate boll ripening and leaf defoliation in harvest preparation. Opportunities exist to leverage novel PGRs to achieve increased crop efficiencies and yield outcomes.

Novel PGRs have recently been demonstrated to enhance overall crop performance and yield, under water-deficit scenarios, in low yielding (American) production systems, studies have also suggested the potential for the use of PGRs in high yielding (irrigated) Australian cotton systems. Such results are suggested as the rationale for further exploration of opportunities to utilise novel PGRs, to create innovative agronomic strategies to address water deficit, and soil abiotic constraints to Australian cotton production systems,

This project aims to utilise applications of novel PGRs to create innovative agronomic management strategies that offer improved crop efficiencies and deliver economic yield and lint quality benefits to Australian rainfed cotton production systems.

Examples of approaches to evaluate may include; increasing root growth to overcome compaction and to improve root foraging of soil water (notably in skip row configurations), as well as manipulating timing and length of flowering to coincide with the peak availability of soil water and optimal climatic conditions.

Method.

Two glasshouse experiments were conducted between June and November 2016, screening trial (I) being repeated twice and the longer duration screening trial (II) being run once only.

Experiments were focused on the manipulation of vegetative growth and development and employed plant morphological changes as a measure of underlying plant physiological responses to PGR treatments.

Agronomic strategies investigated included the initiation of vegetative stasis and / or delay of floral induction, and the promotion of root growth and development, including lateral root system architecture.

Screening trial (I) evaluated foliar applications of cytokinin, gibberellin, auxin, fatty alcohol and phenolic acid PGR treatments, applied at early vegetative stage to enhance root growth and development under optimal growing conditions.

1. ESTABLISHMENT.
14 Treatments, 10 Replicates.
Sterilised, untreated Sicot 746B3F.

2. TREATMENTS.
Foliar, sprayed to drip.
Applied 13 days after planting at 2 true leaves..

3. HARVEST.
23 days after planting.
Root washing, biomass partitioning.

4. ANALYSIS.
Data from 2 exp. repeats pooled and transformed.
ANOVA + Fisher's protected LSD post-hoc.

Screening trial (II) evaluated the capacity of varying dosages of Gibberellin biosynthesis inhibiting hormones to either induce stasis or physiological stunting in early vegetative stage cotton plants, with the aim of delaying floral initiation.

1. ESTABLISHMENT.
9 Treatments, 6 Replicates.
Sterilised, untreated Sicot 746B3F.

2. TREATMENTS.
Foliar, sprayed to drip and soil drench.
Applied 19 days after planting at 4 true leaves..

3. HARVEST.
59 days after planting.
Biomass partitioning, fruit retention mapping, leaf area.

4. ANALYSIS.
ANOVA + Fisher's protected LSD post-hoc.

Results Root Architecture Exp.

	TRT	HEIGHT	RT LGTH	RT DW	LF DW	STM DW	TOT DW	RT%	RT:SHT
Cytokinin	2. 6BA.150ppm	– 83.27	– 96.65	↓ 58.63	↓ 56.98	– 85.23	↓ 62.82	– 97.25	– 94.37
	3. 6BA.25ppm	– 103.36	– 101.93	↓ 63.73	– 92.71	– 99.80	↓ 80.99	↓ 81.35	↓ 70.51
	4. 6BA.33ppm	– 102.10	– 98.92	↓ 69.24	– 99.31	– 105.63	– 88.30	↓ 80.27	↓ 69.20
	5. 6BA.67ppm	– 93.99	– 98.74	↓ 65.32	↓ 83.00	– 98.79	↓ 78.73	↓ 85.37	↓ 78.70
Auxin	6. NAA.20ppm	↑ 107.51	– 91.09	– 100.70	– 97.45	↑ 115.67	– 102.10	– 101.41	– 99.42
	7. NAA.30ppm	– 99.72	– 99.12	– 112.01	– 95.06	– 110.04	– 104.66	– 108.76	– 118.04
Gibberellin	8. GA3.80ppm	↑ 135.55	– 98.16	– 108.51	↓ 89.66	↑ 142.85	– 107.01	– 98.96	– 105.30
	9. GA3.160ppm	↑ 140.71	– 94.92	– 95.87	↓ 90.67	↑ 153.69	– 104.29	– 92.33	– 88.80
Fatty Alcohol	10. TRIA.2.5ppm	– 102.36	– 100.74	– 106.53	– 97.63	– 109.84	– 103.46	– 104.33	– 112.20
	11. TRIA.4.8ppm	– 102.42	– 96.67	– 107.00	– 100.60	↑ 114.98	– 105.82	– 105.90	– 105.59
	12. TRIA.7.5ppm	– 103.17	– 100.41	↑ 145.59	– 105.81	↑ 115.54	↑ 123.69	↑ 115.95	↑ 142.85
Phenolic Acid	13. SA.138ppm	↑ 107.45	– 99.21	↑ 145.63	– 103.53	↑ 120.11	↑ 123.60	– 112.09	– 134.14
	14. SA.691ppm	– 105.94	– 94.04	↑ 204.86	– 99.13	↑ 116.45	↑ 145.08	↑ 123.91	↑ 195.70

Table 1.0. Biomass data for Sicot 746B3F cotton plants harvested 23 days post planting. Arrows indicate occurrence of significant ($P<0.005$) treatment differences from the control means; downward arrows delineating a decrease, upward arrows indicating an increase and a dash being representative of no significant treatment differences from the control means. Values presented are respective percentage differences of the treatment mean from the control mean.

Results Dynamic Fruit Development Exp.

	Trt	Total Biomass	Leaf Biomass	Harvest LA	VGR 10DAT	Nodes 10DAT	VGR Harvest	Nodes Harvest
Stage (I) Inhibitors	2. Chlormequat Chloride (F) 125ppm ai	↓ 55.48	↓ 79.31	– 82.26	– 88.21	↓ 36.84	↓ 51.20	– 83.67
	Mepiquat Chloride (F) 6g ai.ha-1	↓ 69.06	– 86.66	– 89.54	↓ 52.31	↓ 57.89	↓ 50.80	– 95.92
Stage (II) Inhibitors	Paclobutrazol (F) 37.5g ai.ha-1	↓ 39.18	↓ 56.67	↓ 56.70	↓ 23.59	↓ 42.11	↓ 33.78	↓ 59.18
	Paclobutrazol (S) 0.1g.m-3	↓ 20.97	↓ 40.02	↓ 32.42	↓ 19.49	↓ 36.84	↓ 14.90	↓ 28.57
	Uniconazole (F) 30g ai.ha-1	↓ 19.95	↓ 33.66	↓ 34.00	↓ 32.82	↓ 47.37	↓ 28.72	↓ 26.53
	Uniconazole (S) 0.015g ai.m-3	↓ 70.04	– 89.23	– 106.02	↓ 30.77	↓ 73.68	↓ 46.22	– 102.04
Stage (III) Inhibitors	Trinexapac Ethyl (F) 200g ai.ha-1	↓ 61.17	↓ 80.17	– 118.35	↓ 26.32	– 89.47	↓ 58.32	– 106.12
	Prohexadione Calcium (F) 10g ai.ha-1	– 90.54	– 109.18	– 109.70	↓ 52.31	– 101.05	↓ 74.93	– 110.20

Table 2.0. Results for Sicot 746B3F cotton plants treated with gibberellin biosynthesis inhibitors. Arrows indicate occurrence of significant ($P<0.005$) treatment differences from the control means; downward arrows delineating a decrease and a dash indicating no significant treatment differences from the control means. (F) denotes foliar application and (S) denotes soil drench application, both at 4 true leaves. Values presented are respective percentage difference of the treatment mean from the control mean.

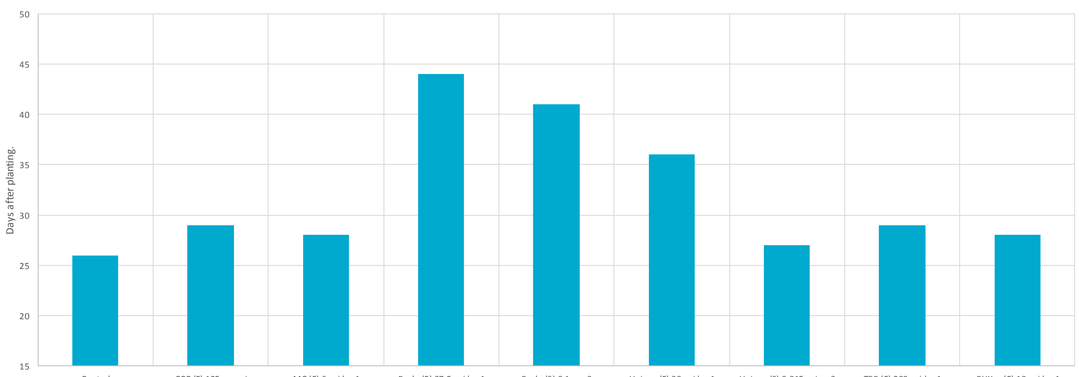

Table 3.0 50% population time to first square (days) for Sicot746B3F cotton plants treated with Gibberellin biosynthesis inhibiting PGRs.

Figures 1.0 Sicot 746B3F plants at 10 DAT; (A) denotes control treatment, (B) denotes Paclobutrazol foliar treatment.

Figures 2.0 Sicot 746B3F plants prior to harvest, 40 DAT; (A) denotes control treatment, (B) denotes Paclobutrazol foliar treatment.

Conclusion and Acknowledgements.

Experiments (I) and (II) demonstrated the utility of specific PGR applications to; improve root growth, being advantageous in improving plant exploration for, and access to water, and to delay early vegetative crop growth and development, which may have advantages in matching crop water use to prevailing climatic conditions.

Data from Exp. (I) established the significant treatment effect of specific fatty alcohol and phenolic acid PGRs in increasing root total dry weight at harvest, and for the role of the phenolic acid PGR in increasing root dry weight proportional to both above ground (shoot) biomass and total dry weight. Exp. (I) also validated the treatment effect of a gibberellin PGR in increasing plant height through an increase in proportional stem growth (stem dry weight).

Data from Exp. (II) substantiated the significant effect of Mepiquat, Paclobutrazol and Uniconazole treatments in decreasing both vegetative growth (VGR) and development (nodes) at 10 days post treatment. Both Paclobutrazol treatments and the uniconazole foliar treatments had extended efficacy through to harvest, with a corresponding treatment impact on total biomass and leaf area. Stage (III) inhibitors Trinexapac Ethyl and Prohexadione Calcium demonstrated significant treatment effects on growth rate (VGR), but not development (nodes) at both 10 days post treatment and harvest.

Future research will include; determining yield impacts and length of treatment efficacy in field based screening experiments, refining application timing and rates under controlled environmental conditions and further investigations to determine mechanisms of PGR action at gene, cell, plant and crop levels.

This project is undertaken in partnership between the Cotton Research and Development Corporation, The University of Sydney and CSIRO Agriculture and Food.

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