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.

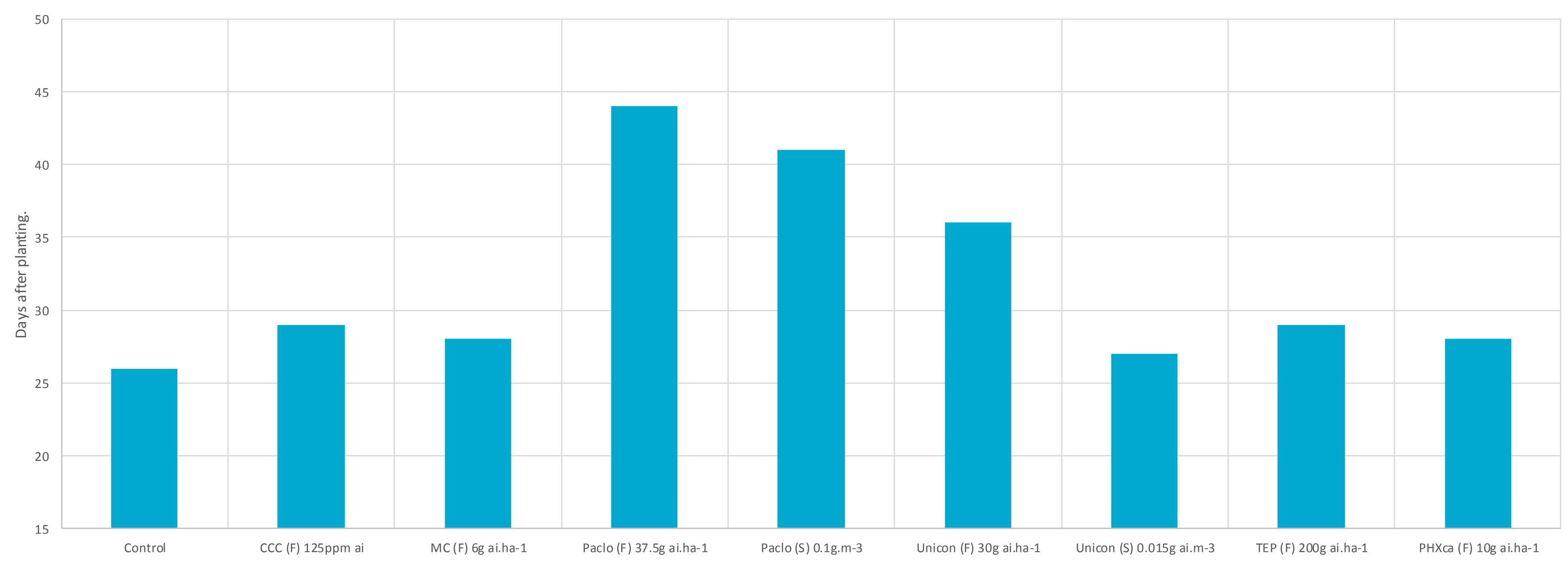
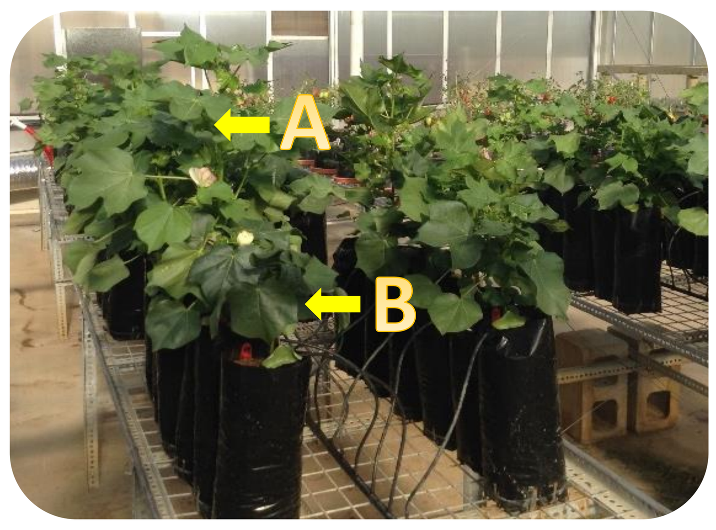


Table 3.0 50% population time to first square (days) for Sicot746B3F cotton plants treated with Gibberellin biosynthesis inhibiting PGRs.

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 plant 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.

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