FINAL REPORT

CRDC ID: CRDC1937

Project Title: Opportunities for Dryland cotton with Bollgard 3

Confidential or for public release? For Public Release

Recognition of support: The Research Provider Dryland Cotton Research Association acknowledges the financial assistance of the Cotton Research and Development Corporation in order to undertake this project.

Part 1 – Contact Details & Submission Checklist

Principal Researcher: **Annabelle Guest DCRA Research Coordinator**
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Submission checklist.

Please ensure all documentation has been completed and included with this final report:

☐ Final report template (this document)
☐ Final Technical Report
☐ Final Schedule 2: IP register
☐ Final Schedule 3: Acknowledgment
☐ Final financial report
☐ PDF of all journal articles (for CRDC's records)

Signature of Research Provider Representative: Annabelle Guest.

Date submitted: 02 Oct 2021

Part 2 - Monitoring & Evaluation

Achievement against milestones in the Full Research Proposal

Milestone	Achieved/ Partially Achieved/ Not Achieved	Explanation
How is more consistent crop establishment achieved? Plant cotton in a range of conditions and measure establishment	*Partially achieved*	*5 Trials were conducted in 2018/19. No trials established in 19/20 (drought) or 20/21 rainfall at inappropriate time didn't allow for planting trials*
Are chemical or mechanical crop termination tactics more effective for cotton crop termination in a multi herbicide tolerant gene stack system? Continue development of chemical and mechanical crop termination tactics	*Partially achieved*	*3 trials conducted in 2018/19. Trials in 2020 not conducted due to COVID-19 travel restrictions. Trials in 2021 not conducted due to equipment delay, lateness of crop and COVID-19 travel restrictions*
How are weeds in the dryland cotton system effectively managed in the absence of glyphosate? Evaluate residual herbicides for weed management leading into and out of dryland systems where cotton is the pillar crop	*Partially achieved*	*Results limited due to drought conditions limiting weed germination*
How is information best communicated to dryland cotton growers? Find and establish a research hub for grower researcher link events.	*Partially achieved*	*Research hub established at University of Sydney "Llara" (no formal agreement) Summer crop field days held at University of Sydney Research site at "Llara" in 2019 and 2021. No summer crop field day held in 2020 (COVID-19) restrictions*

Outputs produced

Output	Description
Reports	*Final Report to CRDC*
Presentations	*Presentation to TIMS committee re using AquaTill for crop termination as Part of the RMP (June 2020)* *Presentation on Aquatill UHP Project Development over three years (Online CCA seminar 2020)* *Presentation to Bayer CropScience on crop termination development with AquaTill (Mar 2020)*

Patents and Agreements	*AquaTill Injeticide multi-row demonstration unit (NDF) prototype*
Extension Resources and Services	*Summer cropping field day University of Sydney Narrabri Article in CRDC Spotlight Magazine Autumn Edition 2020 – New Tool for Crop Termination on the Way*

Outcomes from project outputs *(Refer to examples document).*

Outcome	Description
Extension services	*Growers and industry stakeholders attend summer cropping field day annually*
Commercial agreement	*NDF has agreed to produce AquaTill Injeticide units for commercially for growers (Contract not signed)*
Collaboration	*Growers researchers and commercial agronomists work together on summer crop field day and ongoing research needs for dryland cotton*
Capacity Building	*Undergraduate student works on project and develops expertise in dryland specific research needs with possible future employment*

Part 3 – Technical Report

See Technical Report "CRDC 1937 Opportunities for Dryland Cotton with Bollgard 3® Final Report"

Part 4 – Summary for public release

Project title:	*Error! Reference source not found.*	
Project details:	CRDC project ID:	*CRDC 1937*
	CRDC goal:	*1. Increase productivity and profitability on cotton farms*
	CRDC key focus area:	*1.1 Optimised farming systems*
	Principal researcher:	*Annabelle Guest*
	Organisation:	*Dryland Cotton Research Association Inc*
	Start date:	*01/072018*
	End date:	*30/06/2021*
Objectives	• *Improve tactics with Bollgard 3 to maximise emergence and crop establishment in marginal spoil moisture conditions* • *Improve crop protection with Bollgard 3 to ensure minimal disturbance and prevention of secondary pest carry over* • *Ensure extension information for rain fed production systems Is current and reflects best practice.* • *Optimise productivity In marginal areas.*	
Background	*Rainfed cotton production is expanding in traditional production regions (southern Queensland and Northern NSW) as well as into new regions in northern Australia. This expansion has come about with the availability of insect resistant and herbicide tolerant (Bollgard 3) varieties making insect pest management and weed control easier to achieve.* *Successful dryland cotton production hinges around water use efficiency and optimizing crop rotation within the farming system. Critical factors for production of the crop included seed bed preparation, planting and establishment, weed control and crop termination at the end of the season to inhibit ratoons. The widespread adoption of Bollgard 3® cotton has meant that some changes are required within the farming system to optimize production potential with this technology.*	
Research activities	*Multiple field trials were established from 2018-20 evaluation crop establishment, residual weed control and crop termination at the end of the season. A lot of the trials were unable to be repeated over multiple seasons due to the extreme drought conditions that prevailed over the duration of the project. In conjunction with the field trials, extension of research activities and findings was also evaluated. This led to the establishment of a dryland cropping research hub and the establishment of a summer cropping field day.*	
Output	*A dryland research hub has been established at the University of Sydney Narrabri – "Llara"* *An annual summer cropping field day has been established working collaboratively with Industry research partners*	

	A multi-row Ultra-high Pressure (UHP) cotton termination demonstration machine has been engineered
Impacts	*Collaboration and capacity building for industry with growers, researchers and industry stakeholders exchanging knowledge through the summer cropping field day* *A novel technique of crop termination will be an option for growers in a multigene stack herbicide tolerant crop*
Key publications	1. *CRDC Spotlight Autumn Edition 2020 – New Tool for Crop Termination on the Way* 2. *CRDC Final Report*

CRDC 1937 - Opportunities for Dryland Cotton with Bollgard 3® Final Report

Annabelle Guest

Dryland Cotton Research Association Inc

Project Lead

1. Executive Summary

This project examined four factors identified by the DCRA grower members as the highest priorities for successful dryland cotton production. The four areas identified were:

1. Achieving more consistent crop establishment
2. Evaluating novel crop termination methods (UHP water cutting – Aquatill)
3. Managing weeds in the absence of glyphosate
4. Effective extension of research findings and information to dryland growers through establishment of a dryland research hub

Limited field trials were carried out examining crop establishment in marginal moisture conditions, crop termination using ultra high pressure water cutting and residual herbicides leading into and out of dryland cotton over the course of the project

Severe drought experienced from 2018 to 2020 followed by the COVID-19 pandemic limiting travel and face to face contact made many of the trials to be conducted through this project difficult to achieve and the decision was made to terminate the project.

Looking forward, some useful data was collected over the duration of the project which is a solid base for ongoing work under more favorable weather conditions.

2. Introduction

Expansion of dryland cotton in Eastern Australia has high potential due to its profitability compared to other summer crops and the limitation of water availability for irrigation expansion, particularly in the Murray-Darling Basin. Growers and researchers are continually working on optimizing the farming system for dryland production, particularly as climate change impacts and commodity price fluctuations occur. Successful dryland cotton production hinges around two main factors – optimizing the farming system for profitability and sustainability where cotton is the pillar crop and optimizing water use efficiency within the farming system.

Even and successful crop establishment is crucial to dryland cotton production as often due to the timing and amount of rainfall received, there is only one planting opportunity per season. It is imperative that what when rainfall is received, seed can be planted into moisture providing the best possible germination opportunity. Many types of planters including single and double disc options are used commercially and matching the appropriate planter for the appropriate soil type and moisture conditions are crucial steps to successful establishment.

A high proportion of dryland cotton is both herbicide tolerant and insecticide resistant. Multi-gene stack herbicide tolerant cotton is changing the dryland farming system in two ways – one it is more difficult to terminate the crop in accordance to RMP requirements at the conclusion of the season (fewer herbicide options) and two glyphosate tolerant crops and weeds mean that residual herbicides are increasing in use for extended weed control. The questions addressed through this project aimed to provide tactical options to accommodate these changes in the farming system.

Effective extension of research results to growers and industry is an important outcome and finding a pathway to enable this is also a critical factor to initiate practice change for continued successful dryland cotton production

3. Materials and Methods

3.1 Achieving more consistent crop establishment

3.1.1 2018-19 Season Trials

Five sites were planted from early November to mid-December 2018 into a variety of moisture conditions, soil types and geographical locations including Boggabri, Narrabri, Bullarah, Moree and Terry Hie Hie. The sites were planted using the DCRA planter bar comprising of 5 different units with a row spacing of 1m purchased through project CGA 1703.

The planter bar was mounted to commercial farm equipment at each site. A summary of the sites planted is presented below:

Co-operator	**Tom Greentree**	**University of Sydney**	**Andrew Watson**	**Geoff Manchee**	**Ed Tomlinson**
Farm	"Willow Lea" Bullarah	"Llara" Narrabri	"Kilmarnock" Boggabri	"Bogamildi" Moree	"Carmona Downs" Terry Hie Hie
Planting Date	19/12/18	4/12/18	9/11/18	29/11/18	3/12/18
Soil Type	black clay loam	brown clay loam	Red/Brown clay loam	Heavy Black	Loam to heavy black
Moisture conditions	Marginal	Good	Excellent	Excellent	Marginal
Variety	Sicot 748B3	Sicot 748B3	Sicot 748B3	Sicot 748B3	Sicot 748B3

Establishment was assessed at 10 and 30 days after planting at each site.

3.1.2 2019-20 Season Trials

No trials were planted in 2019 due to severe drought conditions in Northwest NSW (driest on record) and South East Queensland.

3.1.2 2020-21 Season Trials

Trials carried over from 2019/20 to 2020/21 were also not planted due to timing of rainfall for dryland opportunities – October and November were too dry and extensive rainfall in December made conditions too wet and too late to take advantage of a planting opportunity. Operators were also consumed with winter crop harvest over this time which was imperative to cash flow (the first since 2016 for many growers)

3.2 Evaluating novel crop termination methods (UHP water cutting – Aquatill)

3.2.1 2019-20 Season Trials

Three sites were established in June 2019 to evaluate ultra high pressure water cutting (Aquatill Injeticide) for cotton termination. Two sites were established in mulched cotton with one dryland and one irrigated site. A further site was established in standing dryland cotton crop residue. The sites were located at Narrabri, Terry Hie Hie and Dalby as presented below:

Cotton termination sites 2019-20

Co-operator	**University of Sydney**	**Ed Tomlinson**	**James Hayllor**
Farm	"Llara" Narrabri	"Carmona Downs" Terry Hie Hie	"Kensington Park" Dalby
Planting Date	4/12/18	3/12/18	29/11/18
Soil Type	brown clay loam	Loam	Heavy Black
Moisture conditions	Good	Marginal	Marginal
Variety	Sicot 748B3	Sicot 748B3	Sicot 748B3
Crop residue treated	Standing -dryland	Mulched - dryland	Mulched - irrigated

Treatments applied at each termination site 2019-20 are presented below.

University of Sydney Llara – Narrabri (standing)	Carmona Downs – Terry Hie Hie (mulched)	Kensington Park – Dalby (Irrigated mulched)
Fluroxypyr 1 L/ha in 60/79 L	Fluroxypyr 1 L/ha in 79/124 L/ha	Fluroxypyr 1 L/ha in 60/79 L/ha
Fluroxypyr 2 L/ha in 60/79 L	Fluroxypyr 2 L/ha in 79/124 L/ha	Fluroxypyr 2 L/ha in 60/79 L/ha
Water only in 60 L/ha	Water only in 79 L/ha	Water only in 79 L/ha
Untreated Control	Untreated Control	Untreated Control
Commercial (slashed)	Commercial (slashed)	Commercial (mulched)*
Untreated control (slashed)*	Fluroxypyr 1 L in 79 L/ha (standing)*	
	Fluroxypyr 2 L in 79 L/ha (standing)*	

*comparison treatment only – not replicated

Application Details 2019-20 Trials

Site	Volume L/ha	Nozzle	speed kph
Llara	60	0.007	6
	79	0.008	6
Carmona Downs	79	0.008	6
	124	0.01	6
Kensington Park	79	0.008	6
	124	0.01	6

Note: Water volume was increased to 124 L/ha to accommodate larger orifice nozzle. Ratoon Control was assessed in November, December and February at the Terry Hie Hie and Llara sites, the Dalby site was not assessed in December as there was no rainfall to stimulate growth.

3.2.2 2020-21 Season Trials

The following program was planned for the 2020 crop termination work

- Demonstration scale trials - 5-6 sites with NDF multi row unit
- Replicated site in Bollgard 3 XtendFlex® cotton (Locharba) in conjunction with Bayer and evaluation of other herbicides
- Report data to date and submit to APVMA for Fluroxypyr registration through Ultra-high water pressure cutting system
- Present to TIMS committee for consideration as crop termination method in RMP

3.3 Development of Ultra High Pressure Application Equipment

A two-row ground engagement tool developed by Dale Foster at NDF in Narromine in collaboration with SANTFA (South Australian No Till Farmer's Association) was used for cotton termination in the 2019 trials.

Aquatill Injeticide ground engagement tool 2019

Further development of the AquaTill technology and equipment (a multi-row unit) was planned for 2020 based on the recommendations from the previous season's work but no field work was able to be carried out due to the onset of COVID-19 travel restrictions between South Australia and New South Wales in March of 2020. The work planned for 2020 included:

- Demonstration scale trials - 5-6 sites with NDF multi row unit
- A single replicated site in Bollgard 3 XtendFlex® cotton (Locharba) in conjunction with Bayer and evaluation of other herbicides
- Permit submission to APVMA for Fluroxypyr through Ultra-high water pressure system for large scale trials
- Presentation to TIMS committee for consideration as crop termination method in RMP

The development program outlined above was postponed to 2021 but again, weather conditions leading to a very late crop combined with lack of equipment readiness meant that the planned work was delayed until August 2021. The week the demonstrations were to take place saw regional NSW

enter a statewide lockdown due to COVID-19 and travel restrictions did not allow for the work to take place.

3.4 Regulatory Requirements

A permit for application of Fluroxypyr through the Aquatill Injeticide system was deemed necessary for large scale trial work (more than 1 ha per season) to be conducted and a data review was carried out to identify data gaps to be filled prior to applying for an APVMA registration.

3.5 Managing Weeds in the Absence of Glyphosate

Residual weed control was examined in the system at two stages - leading out of dryland cotton for ratoon and weed control and leading in to dryland cotton for crop safety and weed control. A total of three field trials were carried out over the project duration in extremely dry circumstances.

3.5.1 2018-19 Trial

A single residual herbicide demonstration trial was conducted at the University of Sydney site at "Llara" Narrabri over the 2018/19 season for comparison of residual herbicides leading into dryland cotton. The trial included pre-plant and post plant pre-emergence treatments. Treatments were applied on the 19 November 2018 at the time of planting the commercial crop. Crop damage to cotton was assessed visually. The treatments included in the trial are presented below:

Treatments	Treatment	Active	MOA Group	Rate
1	Untreated Control	-	-	-
2	Rifel 440	440 g/L Pendimethalin	D	3.3 L/ha
3	Triflur X	480 g/L Trifluralin	D	3.2 L/ha
4	Clincher Gold	960 g/L S-metolachlor	K	1 L/ha
5	Terbyne Xtreme	875 g/kg Terbuthylazine	C	1.2 kg/ha
6	Diuron 900 WG	900 g/kg Diuron	C	2 kg/ha
7	Clincher Gold	960 g/L S-metolachlor	K	1 L/ha
7	Terbyne Xtreme	875 g/kg Terbuthylazine	C	1.2 kg/ha
8	Clincher Gold	960 g/L S-metolachlor	K	1 L/ha
8	Diuron 900 WG	900 g/kg Diuron	C	2 kg/ha
9	Sharpen	700 g/kg saflufenacil	G	34 g/ha
10	Valor	500 g/kg flumioxazin	G	280 g/ha
11	Cotogard	440 g/kg prometryn + 440 g/kg fluomenturon	C	2.9 kg/ha
12	Prometrex 900 WG	900g/kg prometryn	C	2.5 kg/ha

3.5.2 2019-20 Trials

Two further trials were established in 2019, one site was established in winter 2019 at Narrabri to investigate residual herbicides leading out of dryland cotton and their effectiveness for ratoon control the following spring.

A further site was established in summer 2019/20 to investigate residual herbicides leading into dryland cotton and determine crop safety.

Trial 1 – Residual Herbicides leading out of Dryland Cotton – Ratoon Control – Treatment List

Treatment	Product	Active	Rate	Unit
1	Tordon Fallowboss	300 g/L 2,4-D 75 g/L PICLORAM 7.5 g/L AMINOPYRALID	1000	ml/ha
2	Tordon 75D	301 g/L 2,4-D 75 g/L PICLORAM	1000	ml/ha
3	Grazon extra	300 g/L TRICLOPYR 100 g/L PICLORAM 8 g/L AMINOPYRALID	500	ml/ha
4	Pixxaro	250 g/L FLUROXYPYR 16.25 g/L HALAUXIFEN	600	ml/ha
5	Stinger	375 g/kg AMINOPYRALID 300 g/kg METSULFURON-METHYL	14	g/ha
6	Stuka Flexi	240 g/L PICLORAM	300	ml/ha
7	Balance	750 g/kg ISOXAFLUTOLE	100	g/ha
8	Terbyne	750 g/kg TERBUTHYLAZINE	2000	g/ha
9	Palmero TX	750 g/kg TERBUTHYLAZINE 75 g/kg ISOXAFLUTOLE	1000	g/ha
10	Spinnikar	700 g/kg IMAZETHAPYR	100	g/ha
11	Valor	500g/kg FLUMIOXAZIN	280	g/ha
12	Sharpen	700g/kg SAFLUFENACIL	34	g/ha
13	Dual Gold	960 g/L S-METOLACHLOR	2000	ml/ha
14	Diruon	900g/kg DIRUON	2000	g/ha
15	Flame	240 g/L IMAZAPIC	150	ml/ha
16	Atrazine	900g/kg ATRAZINE	2000	g/ha
17	Stomp	440 g/L PENDIMETHALIN	3000	ml/ha
18	Glean	750 g/kg CHLORSULFURON	20	g/ha
19	Palmero TX +	750 g/kg TERBUTHYLAZINE 75 g/kg ISOXAFLUTOLE +	1000	g/ha
	Dual Gold	960 g/L S-METOLACHLOR	2000	ml/ha
20	Palmero TX +	750 g/kg TERBUTHYLAZINE 75 g/kg ISOXAFLUTOLE +	1000	g/ha
	Flame	240 g/L IMAZAPIC	150	ml/ha
21	Balance	750 g/kg ISOXAFLUTOLE	100	g/ha
	Diruon	900g/kg DIRUON	2000	g/ha
	Dual Gold	960 g/L S-METOLACHLOR	2000	g/ha
22	Balance	750 g/kg ISOXAFLUTOLE	100	g/ha
	Diruon	900g/kg DIRUON	2000	g/ha
	Flame	240 g/L IMAZAPIC	150	ml/ha
23	Tordon 75D	301 g/L 2,4-D 75 g/L PICLORAM	1000	ml/ha
	Flame	240 g/L IMAZAPIC	150	ml/ha
24	Stuka Flexi+	240 g/L PICLORAM	300	ml/ha
	Stinger	375 g/kg AMINOPYRALID 300 g/kg METSULFURON-METHYL	14	g/ha
25	Uragan	800 g/kg BROMACIL	1000	g/ha
26	Uragan	801 g/kg BROMACIL	2000	g/ha
27	Balance +	750 g/kg ISOXAFLUTOLE	100	g/ha
	Atrazine +	900g/kg ATRAZINE	2000	g/ha
	Dual Gold	960 g/L S-METOLACHLOR	2000	g/ha
28	Stuka Flexi+	240 g/L PICLORAM	300	ml/ha
	Glean	750 g/kg CHLORSULFURON	20	g/ha
29	Stuka Flexi+	240 g/L PICLORAM	300	ml/ha
	Balance	750 g/kg ISOXAFLUTOLE	100	g/ha
30	Stuka Flexi+	240 g/L PICLORAM	300	ml/ha
	Balance +	750 g/kg ISOXAFLUTOLE	100	g/ha
	Stinger	375 g/kg AMINOPYRALID 300 g/kg METSULFURON-METHYL	14	g/ha

Trial 2 – Residual Herbicides leading into Dryland Cotton - Crop Safety and Weed Control Treatment List

A single replicated trial was established at the University of Sydney PBI in December 2019. The site was watered and cotton planted in December. The treatments were applied PSPE (post sowing pre emergence) and the site was watered again prior to after planting

Treatments	Treatment	Active	MOA Group	Rate
1	Untreated Control	-	-	-
2	Rifel 440	440 g/L Pendimethalin	D	3.3 L/ha
3	Triflur X	480 g/L Trifluralin	D	3.2 L/ha
4	Clincher Gold	960 g/L S-metolachlor	K	1 L/ha
5	Terbyne Xtreme	875 g/kg Terbuthylazine	C	1.2 kg/ha
6	Diuron 900 WG	900 g/kg Diuron	C	2 kg/ha
7	Clincher Gold	960 g/L S-metolachlor	K	1 L/ha
7	Terbyne Xtreme	875 g/kg Terbuthylazine	C	1.2 kg/ha
8	Clincher Gold	960 g/L S-metolachlor	K	1 L/ha
8	Diuron 900 WG	900 g/kg Diuron	C	2 kg/ha
9	Sharpen	700 g/kg saflufenacil	G	34 g/ha
10	Valor	500 g/kg flumioxazin	G	280 g/ha
11	Cotogard	440 g/kg prometryn + 440 g/kg fluomenturon	C	2.9 kg/ha
12	Prometrex 900 WG	900g/kg prometryn	C	2.5 kg/ha

3.6 Extension

Negotiations were initiated with the University of Sydney to formally establish a research hub at the Narrabri commercial farm "Llara". The DCRA president and research coordinator presented to Alex McBratney and Steve Cattle (See presentation link in the appendices)

A survey was conducted in July 2018 to best gauge how dryland growers would prefer to receive information from research projects. The survey which was targeted at dryland growers had 25 respondents and included the Question "What is your preferred Method for presentation of research results".

A working group was also established among industry stakeholders in dryland cotton production to commence an annual summer cropping field day. The stakeholders involved were DCRA, University of Sydney, CSD, Cotton Info and CSIRO.

4. Results and Discussion

4.1 Achieving More Consistent Crop Establishment

In the 2018 trials establishment was assessed at 10 and 30 days after planting at each site. A summary of establishment results is presented below. Note SD = single disc, DD = double disc. Manufacturers are not identified.

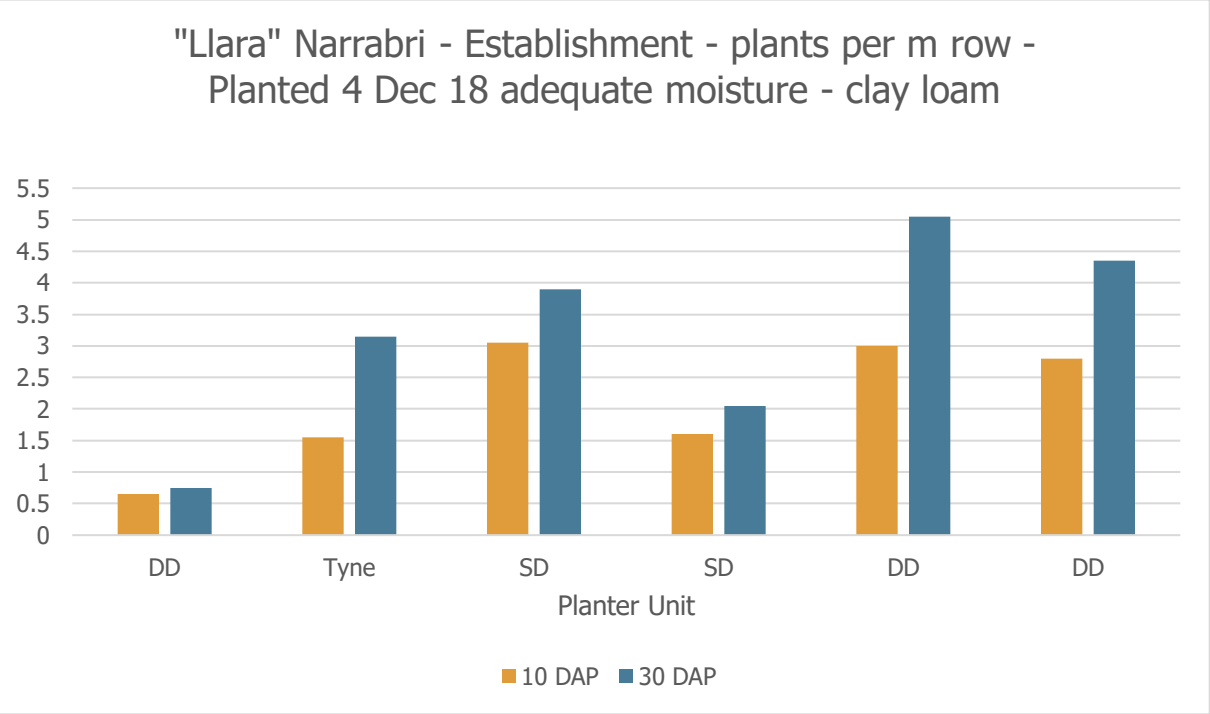


Figure 1 Results from Llara – Narrabri 2018/19

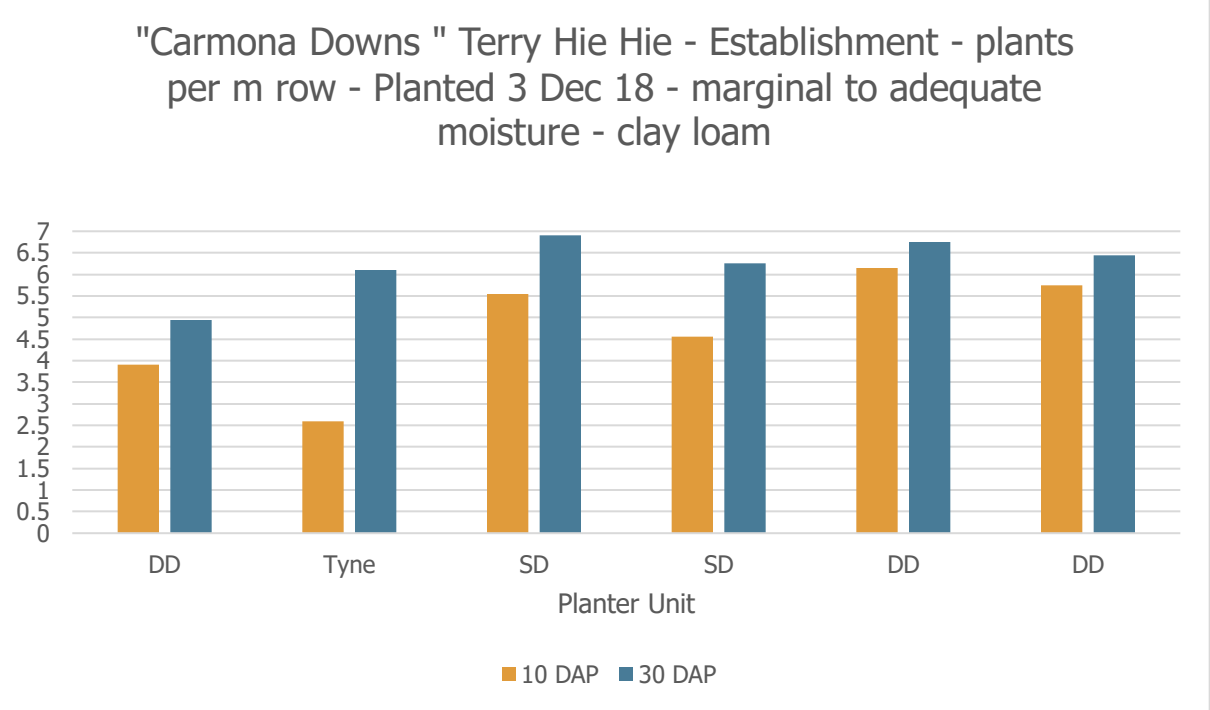


Figure 2 Results from "Carmona Downs" – Terry Hie Hie 2018/19

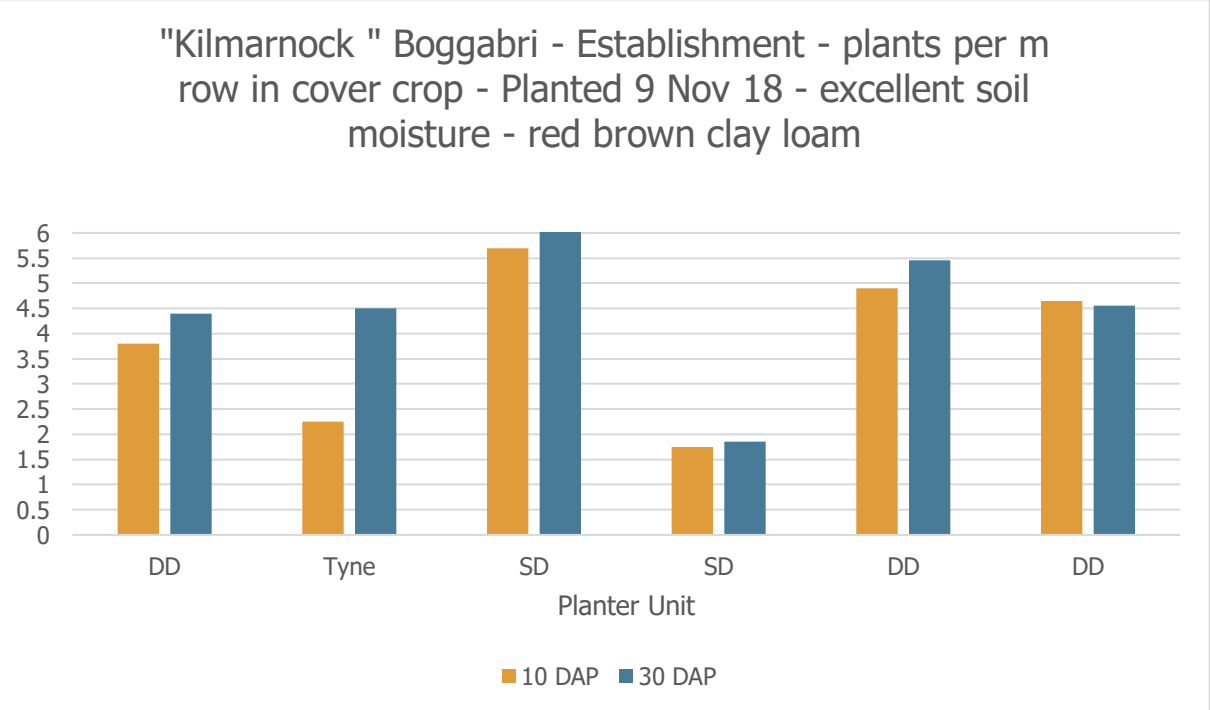


Figure 3 Results from "Kilmarnock" cover crop – Boggabri 2018/19

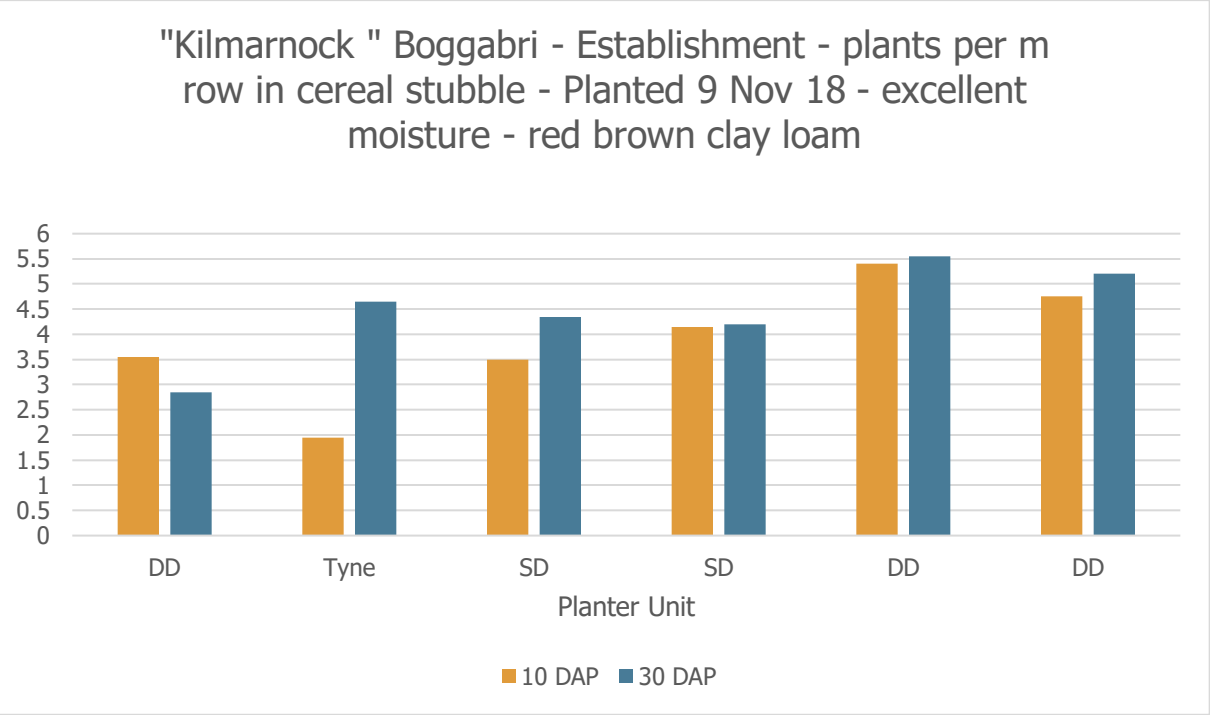


Figure 4 Results from "Kilmarnock" cereal stubble – Boggabri 2018/19

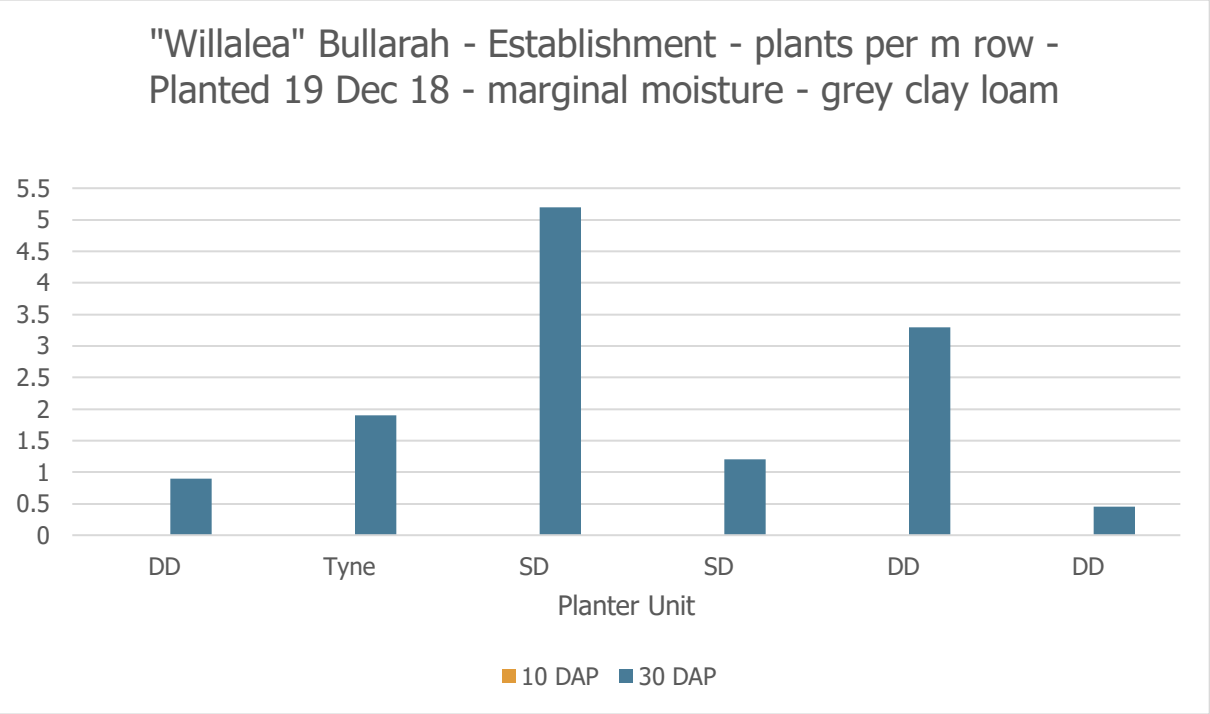


Figure 5 Results from "Willalea" - Bullarah 2018/19

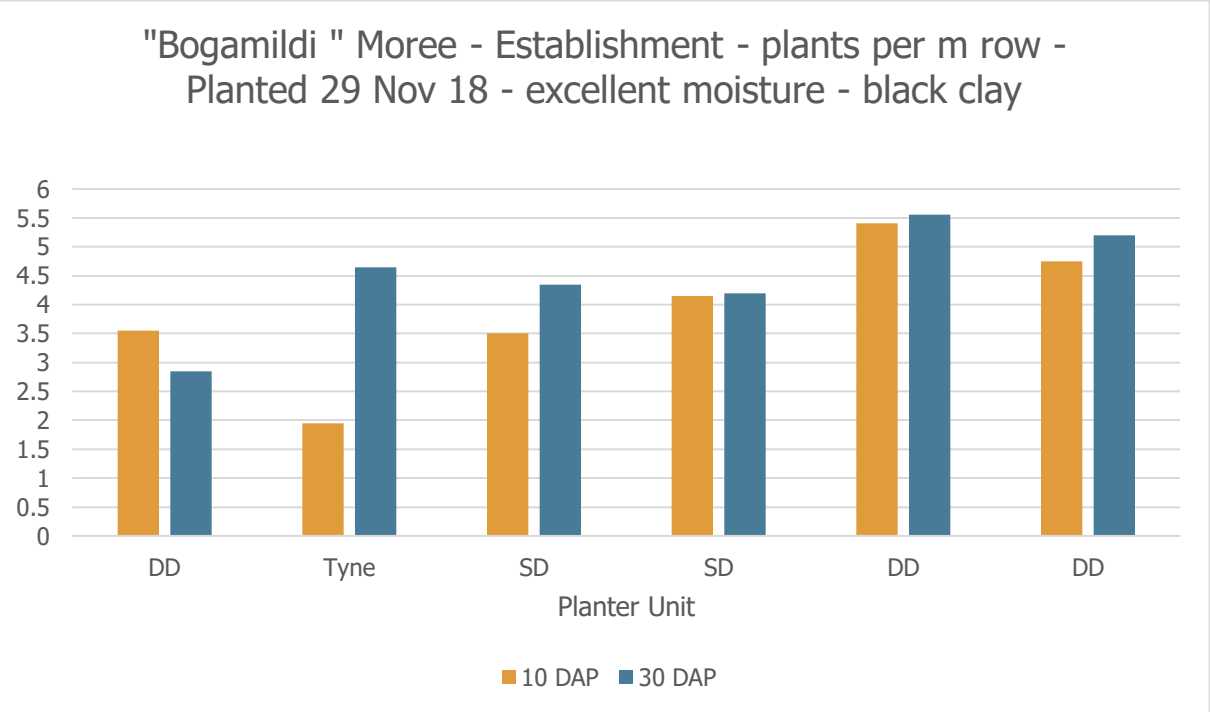


Figure 6 Results from "Bogamildi" - Moree 2018/19

Each planter unit provided some benefits in different soil moisture conditions. The single disc units were able to put the seed in deeper moisture with less soil disturbance but the seedling vigor was limited through a longer path to emergence. In some cases, it followed the disc cut which placed the seed too deep to emerge successfully. The tyne was able to reach the moisture but the exposed wet soil did dry out quicker limiting moisture availability for emergence.

Recommendations:

1. Modify and upgrade units in conjunction with manufacturers prior to 2019 planting
2. Do more work to optimise performance of the closing wheel.
3. Repeat the trial series in 2019 and plant in a variety of geographical areas, soil types and moisture conditions
4. Continue to invite manufacturers to all sites to ensure their unit is properly set up to achieve the best establishment at each location

The planter bar was to undergo modification to meet these recommendations. A double disc unit from Boss Engineering was considered for mounting on the bar and Furrowforce technology from Precision Seeding solutions was also considered, see link https://www.pssag.com/resources/furrow-force-defies-the-force-of-nature.php

Correct planter setup tailored to individual fields is critical to successful establishment. A finding from this work was that each of the manufacturers wanted to be present in the field at the time of planting to ensure their unit was correctly set up for the field situation. The logistics of organising the 6 different companies to be at the same location on multiple occasions was challenging and limited work going forward after 2018. Severe drought did not allow for a planting opportunity in 2019. The timing of rainfall also limited the planting opportunity in 2020 as the rain fell over December and resources were unable to be found at this time of the year with commercial summer crop planting. The DCRA is now considering modifying the planter bar into a trial planter so that it can be more effectively utilized for establishment trials.

4.2 Evaluating novel crop termination methods (UHP water cutting – Aquatill)

4.2.1 2019/20 Season Trials

Fluroxypyr at 1 and 2 L/ha gave robust control of ratoons (95 to 100%) through to February (Figure 1). Control was higher than water alone and seemingly higher than the commercial sprayed treatment (comparison only)

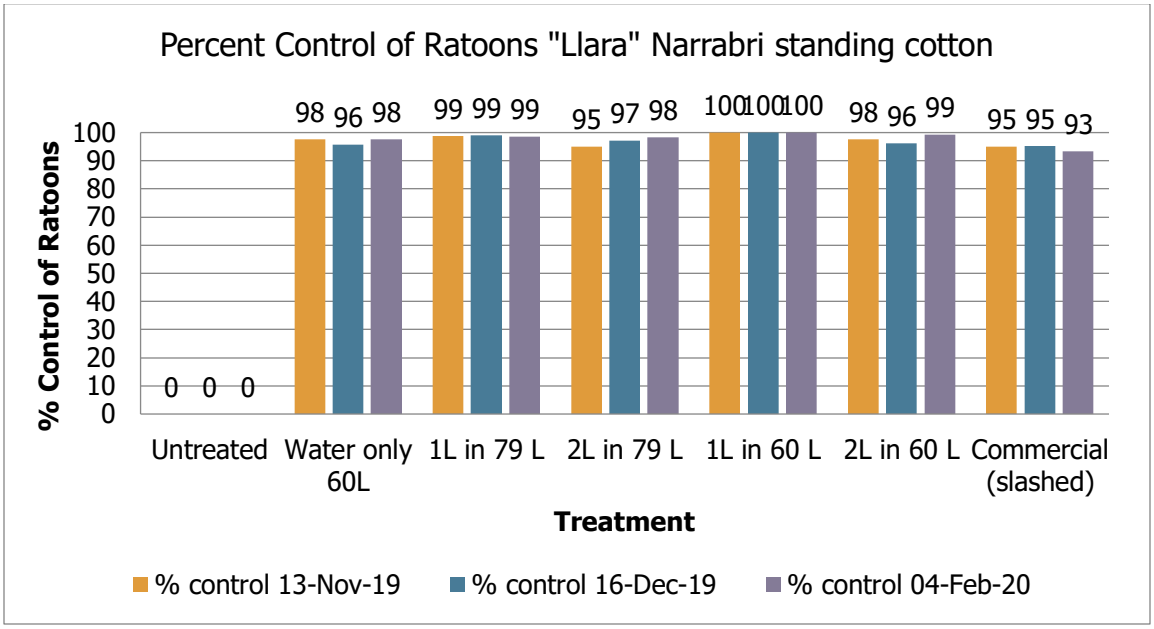


Figure 7 Results from Llara – Narrabri 2019/20

Fluroxypyr at 2 L/ha gave robust control of ratoons (94%) through to February. Control was higher than water alone and seemingly higher than the commercial sprayed treatment (comparison only). Fluroxypyr at 1 L/ha did not achieve commercially acceptable control (95%) in either slashed or standing stubble.

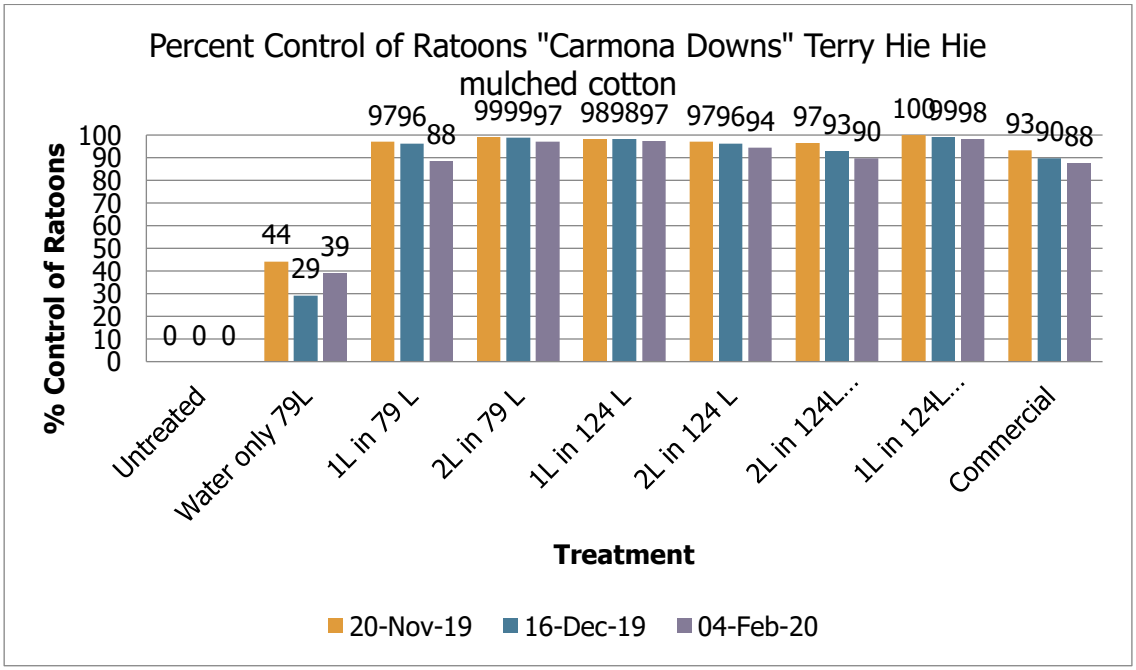


Figure 8 Results from Carmona Downs Terry Hi Hie 2019/20

Fluroxypyr at 1 and 2 L/ha gave robust control of ratoons (94% to 98%) through to the end of January (Figure 5). Control was higher than water alone and seemingly higher than the commercial sprayed treatment (comparison only)

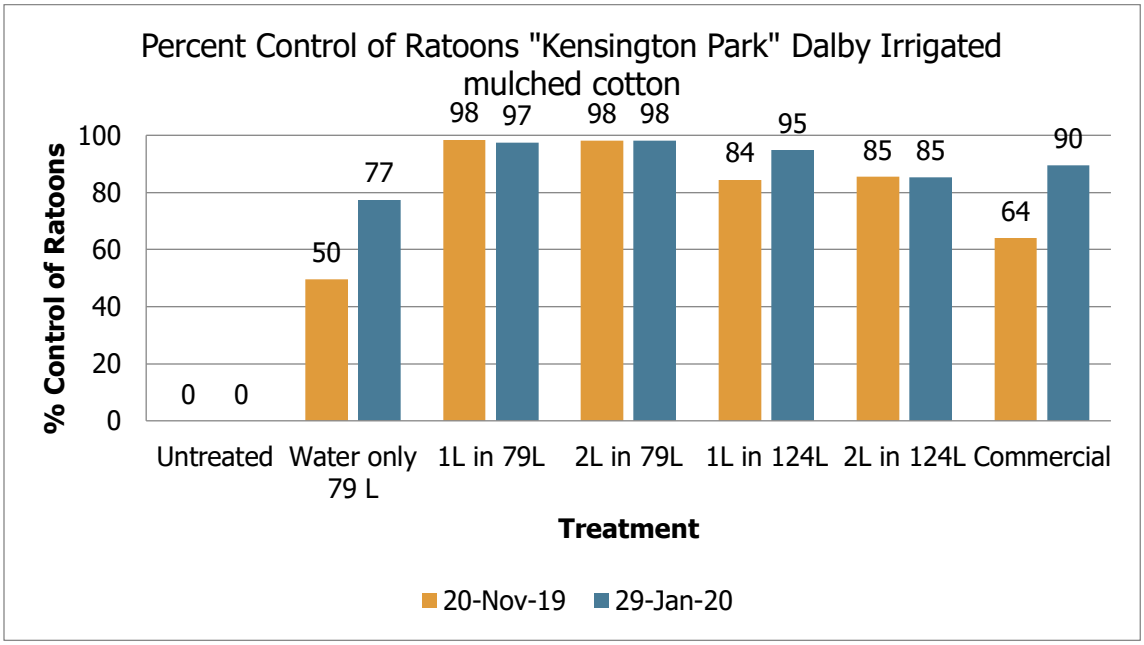


Figure 9 Results from Kensington Park Dalby 2019/20

Recommendations*:*

- Increasing the Fluroxypyr rate from 1 L/ha to 2L/ha increased control but increased cost to commercially prohibitive levels
- Increasing water volume did not consistently lead to increased efficacy
- Anecdotal evidence suggested standing stubble ratoons less than mulched/slashed cotton - more data required on standing vs slashed/mulched stubble

4.2.2 2020/21 Season Trials

No field trials were established in 2020 due to COVID-19 travel restrictions preventing travel from South Australia to New South Wales and national lockdown.

4.3 Development of Ultra High Pressure Application Equipment

A multi row (treats 4 rows) AquaTill "cotton killer" demonstration unit engineered by NDF at Narromine has been purchased in September 2021 by DCRA (see photos below) and is available for future trials in 2022. The demonstration machine has been tested on ground at Narromine and located at Narrabri so that future demonstrations should be less dependent on interstate travel restrictions. Demonstrations are planned for 2022 as well as some work in Xtend Flex® cotton in conjunction with Bayer CropScience.



Figure 10 Demonstration unit 2021 and ground engagement Tool

In parallel UHP water pressure technology for cotton termination is being developed using an upcycled cotton picker by a grower on the Darling Downs. A single demonstration day with the technology was held near Dalby in July 2021.



Figure 11 Upcycled cotton picker Unit Demonstration Dalby July 2021

4.4 Regulatory Requirements

APVMA permit PER89361 for the use of Fluroxypyr at rates of 0.5 to 1.0 L/ha for cotton termination via the AquaTill system was applied for and is in place from 4 April 2021 until 30 April 2023 (See Appendices). This permit will cover any field trials to be completed in the 2022 season.

4.5 Managing weeds in the absence of glyphosate

4.5.1 2018-19 Trial Results

No weeds emerged in the trial due to the extremely dry conditions. A selection of visual crop damage images from 21 January 2019 are presented below:


Untreated
Control


Rifel 440
440 g/L Pendimethalin
3.3 L/ha


Triflur X
480 g/L Trifluralin
3.2 L/ha


Clincher Gold
960 g/L S-metolachlor
1 L/ha


Terbyne Xtreme
875 g/kg Terbuthylazine
1.2 kg/ha


Diuron 900 WG
900 g/kg Diuron
2 kg/ha


Terbyne Xtreme
875 g/kg Terbuthylazine
1.2 kg/ha


Clincher Gold
960 g/L S-metolachlor
1 L/ha
Diuron 900 WG
900 g/kg Diuron
2 kg/ha

4.5.2 2019-20 Trial Results

Trial 1 – Residual Herbicides leading out of Dryland Cotton – Ratoon Control

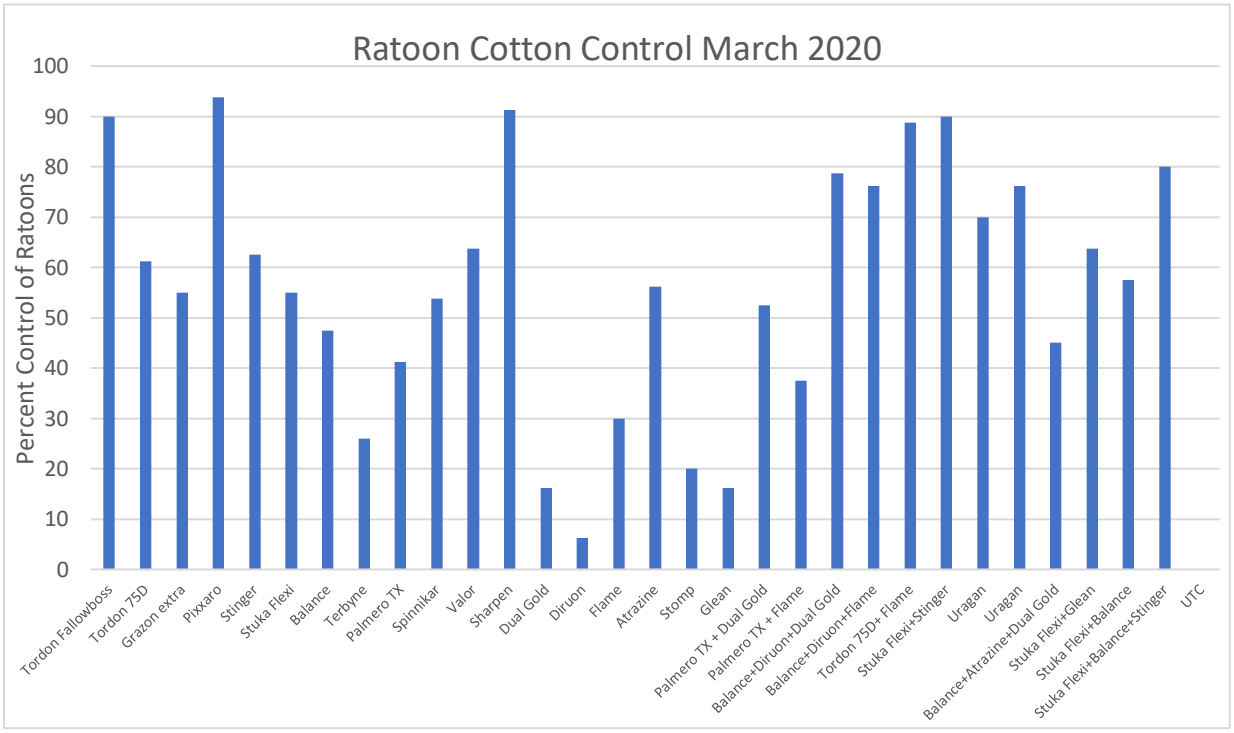


Figure 12 Percent Control of Ratoons – March 2020

Due to extremely dry conditions between July 2019 and January 2020, many of the treatments were not activated until summer rainfall was received. As the rain was 6 months after application, the results were quite variable, however, trends indicate that the residual chemistry remained active until rainfall was received. Some degradation of active ingredient was likely hence some products performed more poorly than expected.

The substantial rainfall between January and March may have affected plantback windows and the safety to subsequent crops, in this case durum wheat was planted in early June. If the rain had fallen more normally, ratoon control would have been commercially acceptable and plantback windows of the herbicides evaluated would have been compatible with the crop rotation.

Pixxaro, Tordon Fallow Boss and Sharpen all performed reasonably well (90% control or higher and warrant further evaluation. These products also warrant investigation through the Aquatill crop termination system.

Trial 2 – Residual Herbicides leading into Dryland Cotton Crop Safety and Weed Control

Crop Safety

An assessment of crop safety was made in January 2020 by measuring plant establishment and crop biomass (NDVI) as in indication of crop vigor

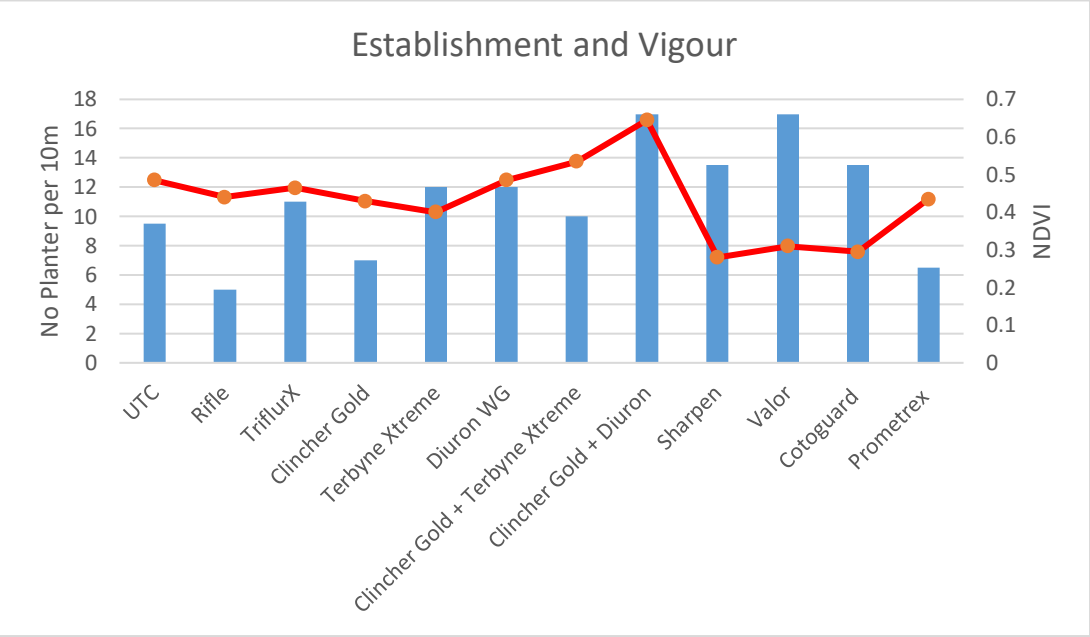


Figure 13 Plant Establishment and Biomass – January 2020

The emergence and establishment were extremely variable due to the dry weather conditions and resulted in a patchy plant stand therefore the plant counts did not truly reflect herbicide activity. Vigor results (NDVI) were consistent with past trials.

Weed Control –Weed control was assessed through visual observation – see treatment photos below:

Untreated Control

Rifle

TriflurX

Clincher Gold

Terbyne

Diuron

Clincher + Terbyne

Clincher + Diuron

Sharpen

Valor

Cotogard

Prometrex

Again, results were variable results due to dry conditions. Sharpen and Cotogard provided good residual yellow vine control the other treatments provided poor control. Sharpen is not registered for weed control in cotton and does not fit into the rotation system due to the plantback restrictions

Cotogard is older chemistry and was included to examine residual grass weed control (feather top rhodes and windmill grass)

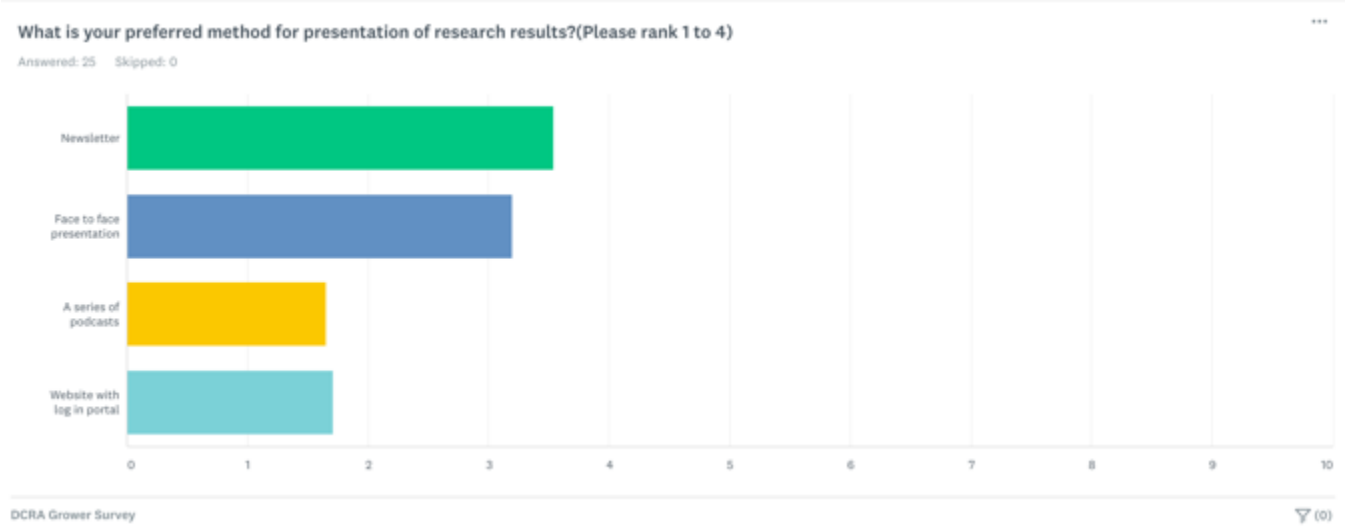
The commercial standard treatment Diuron plus Clincher Gold was safe to the crop and did not affect plant stand or vigor. The other commercial treatment (Terbyne + Clincher Gold) affected crop vigor more than Diuron plus Clincher Gold which was an expected result.

The weed control and crop safety results from this trial reflected those from the previous season but the treatments need to be repeated in a more normal rainfall season to confirm the effects and to assess activity on hard to control grass weeds (feather top Rhodes, windmill grass and barnyard grass)

4.6 Extension

A collaborative working relationship with the University of Sydney has allowed the dryland research field trials to be conducted at the University of Sydney farm "Llara" located near Narrabri although no formal agreement has been put in place (see link to presentation in Appendix 1.2**)**

Through the results of the survey which indicated that the preferred methods for extension of research results was via newsletter and face to face (See table below). A summer cropping field day was established in 2019 through a collaborative effort between the University of Sydney, DCRA, CSD, CSIRO Cotton Info and other industry bodies.



A further field day was planned in 2020 but was cancelled due to CCOVID-19 restrictions. A Summer cropping field day was held in 2021 and was smaller in nature due to a COVID-19 outbreak in Queensland restricting travel for some potential attendees.

5. Conclusions

5.1 Establishment

In marginal moisture conditions single disc and double disc units are more effective in placing seed onto moisture, however, seedling vigor may be impacted by the depth of planting required to place the seed into moisture. Evaluation of the Furrow Force technology from Precision Seeding Solutions is warranted. Planting into optimal soil moisture was not examined in this project and also warrants investigation although planter type is not as critical under optimal conditions.

While the concept of having planting units from multiple manufacturers is a good one, in reality this is logistically difficult to manage so the planter bar would be of more benefit if modified into a trial plant with multiple units from the same manufacturer.

5.2 Crop Termination – UHP AquaTill Injeticide

Trials carried out under this project have ground truthed UHP technology for crop termination and ratoon control using herbicide (Fluroxypyr) in conjunction with the UHP technology. Further development is warranted evaluating different herbicides through the unit for the termination of Xtend Flex cotton and this work should be continued in collaboration with Bayer CropScience and TIMS to ensure compliance with the RMP.

Development of the ground engagement tool is almost at a commercial stage, however, the manufacturer (NDF) who was worked with under this project is unsure of their commitment level to commercially produce the ground engagement units. This is a crucial step in commercialization as is access to the UHP pumps from Flow. Continued collaboration with SANTFA would help with the success of this technology.

5.3 Weed Control in the Absence of Glyphosate

Pixxaro (fluroxypyr plus halauxifen), Tordon Fallow Boss (2,4-D plus picloram plus aminopyralid) and Sharpen (saflufencacil) indicated effective control of ratoons coming out of cotton and further replicated work is warranted. These products also warrant investigation through the UHP Aquatill crop termination system.

Leading into cotton, the commercial treatments were safe to the crop and did not affect plant stand or vigor but the weed control and crop safety results from the treatments evaluated need to be repeated in a more normal rainfall season to confirm effects seen in this preliminary work and to assess activity on hard to control grass weeds (feather top Rhodes, windmill grass and barnyard grass)

5.4 Extension

While a dryland research hub has been informally established at "Llara", a formal agreement with the University of Sydney has not been put in place. The stakeholder collaboration between the University,

DCRA, CSIRO, CSD and other bodies is building successfully with the University site hosting a CSIRO conventional breeding site in the 20/21 season.

This collaboration which led the to the establishment of the summer cropping field day with the inaugural event held in 2019. The attendance indicated keen interest in this event across the region with attendees coming from a range of geographical regions. This event is now cemented in the cotton calendar and should continue annually once COVID restrictions ease.

6. List of Outputs

1. University of Sydney Summer Crop Field day 28 March 2019
2. University of Sydney Summer Crop Field Day 30 March 2021
3. CCA cropping solutions seminar online presentation June 2020 – Using ultra high pressure water cutting for cotton termination – progress from 3 years of development
4. TIMS Committee Online presentation 2020 – Using ultra high pressure water cutting for cotton termination – progress from 3 years of development
5. Presentation to Bayer CropScience March 2020 on Using ultra high pressure water cutting for cotton termination – progress from 3 years of development

7. Appendices

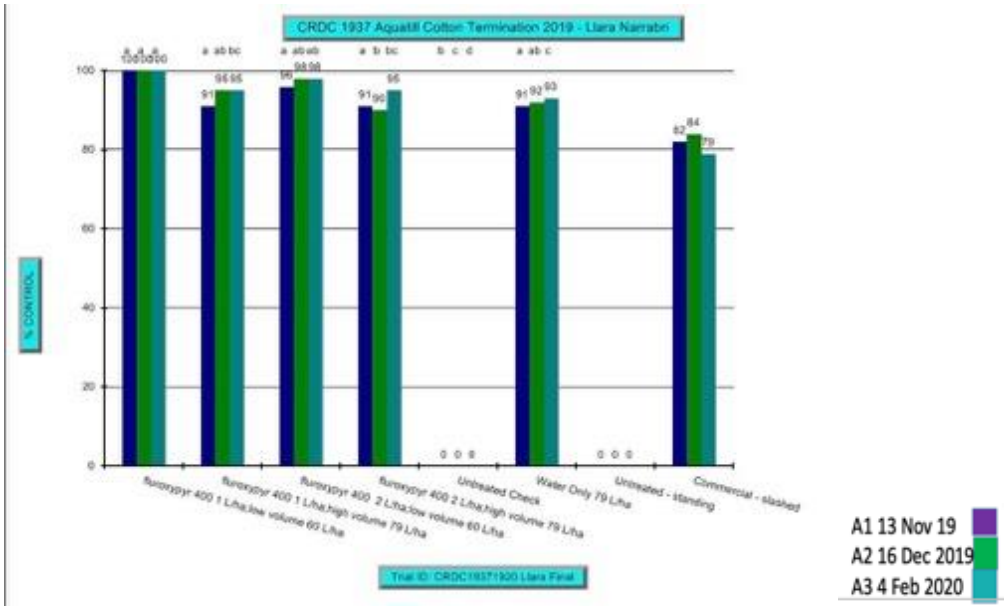
1 Presentation to University of Sydney

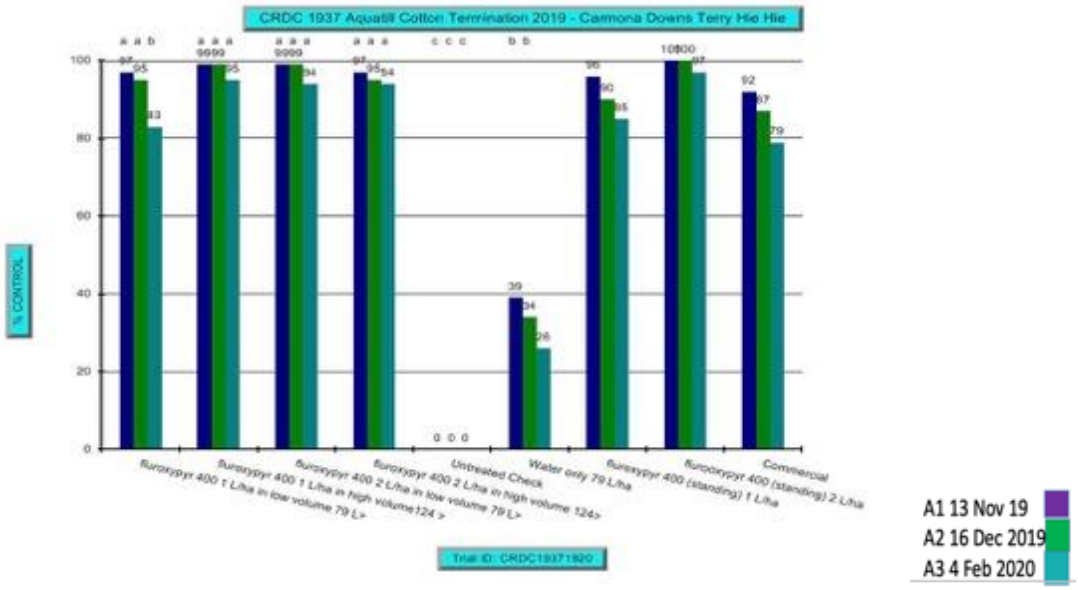
University of Sydney Presentation

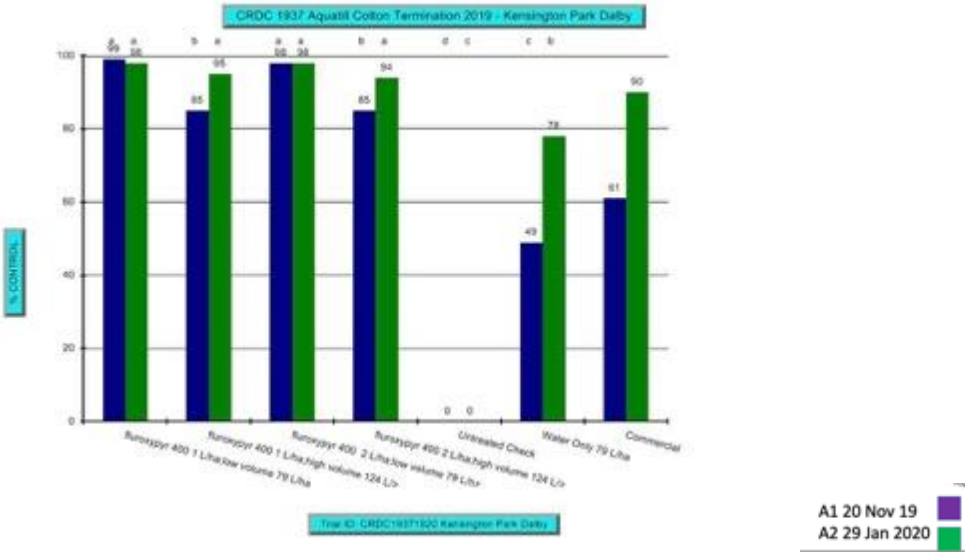
2 Presentation to TIMS

../Google Drive/DCRA Project Files/CRDC1937/Final report documents/CCA Aquatill Presentation 2020 TIMS.pdf

3 Raw Data – Aquatill trials




CRDC 1937 Aquatill Cotton Termination 2019 - Carmona Downs Terry Hill Hill
% CONTROL
Trial ID: CRDC19371920
A1 13 Nov 19
A2 16 Dec 2019
A3 4 Feb 2020


CRDC 1937 Aquatill Cotton Termination 2019 - Kensington Park Dalby
% CONTROL
A1 20 Nov 19
A2 29 Jan 2020

4 APVMA Permit

PERMIT TO ALLOW RESEARCH USE OF A REGISTERED

AGVET CHEMICAL PRODUCT FOR CONTROL OF RATOON COTTON

AND TERMINATION OF CROPS

PERMIT NUMBER – PER89361

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows the Permit Holder and any person stipulated below to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 4 APRIL 2021 TO 30 APRIL 2023

Permit Holder:
TITAN AG PTY LTD
15/16 Princes Street
NEWPORT NSW 2106

Persons who can use the product under this permit:
Persons identified below who are involved in evaluation of the AQUA-TILL® Jetacide (TM) technology:

Dale Foster
Greg Butler
Annabelle Guest
Garry Ronnfeldt

5 Summer Cropping Field Day Flyers

Summer Cropping Field Day

When: 1pm Thursday 28 March 2019.

Where: Conference Room, University of Sydney, I.A. Watson Grains Research Centre, Newell Highway, Narrabri.

Travel between sites on a courtesy bus

Day concludes with a BBQ at 5pm.

Field trial presentations/demonstraions include:

- **Cover crops – Dr Asad Shabbir, USyd.**
- **Summer crop residual herbicides – Harry Pickering, ADAMA.**
- **Stripper front stubble management – Annabelle Guest, DCRA.**
- **Cotton variety and row spacing - Bob Ford, CSD.**
- **Cotton planter bar – Geoff Hunter, DCRA.**
- **PGR's and dryland cotton growth and development – Dr. Michael Bange. CSIRO.**
- **Aquatill cotton termination – Annabelle Guest, DCRA.**
- **Weed Chipper – Dr. Michael Walsh, USyd.**

RSVP by Monday, 25 March to Melissa Eather Ph. 67992205,
Melissa.Eather@sydney.edu.au

This event is supported by Northern Slopes Landcare Association and the Regional Landcare Facilitator through funding from the Australian Government's National Landcare Programme

2021 SUMMER CROP FIELD DAY

Tuesday, 30 March 2021
University of Sydney
I.A. Watson Grains Research Centre
Newell Highway, Narrabri

MARCH
30

11AM - 1PM Indoor Session One

- DCRA Projects Update, Annabelle Guest, DCRA.
- New Project Ideas, Ian Gourley, DCRA.
- Picking vs Stripping in Higher Yielding Cotton, Dr Rene van der Sluijs, Textile Technical Services.
- Sandblasting Reduction Using Sorghum, Chris Maunder, B&W Rural.
- Dryland Variety Trial Results 2021, Bob Ford, CSD.
- Adaptive Management of Dryland Systems, Dr Claire Welsh, CSIRO.
- NGA Residual Herbicide Trial, Drew Penberthy, Outlook Ag.

1PM BBQ Lunch

- Native Grains Project, Dr Angela Pattison, University of Sydney.

2PM Bus to "Llara" Field Demonstrations

- DCRA Stubble Height and Crimped Rye Systems Trial, Mitch Cuell, Outlook Ag.
- Robot Launch, University of Sydney.
- Carbon Sequestration in Cropping, Prof. Alex McBratney, University of Sydney.
- What's New in Planter Technology, Anton Kowalenko, John Deere.
- Dryland Breeding Trial Varieties, Dr Warren Conaty, CSIRO.
- IPM in Dryland Cotton and Releasing Beneficials, Dr Mary Whitehouse, CSIRO and Parabug.
- Using Predators Over Sprays; A Grower's Perspective, Andrew Watson, Boggabri NSW.

THE DAY WILL CONCLUDE WITH SOCIAL DRINKS AND SNACKS

OUTLOOK AG
THE UNIVERSITY OF SYDNEY Institute of Agriculture
DCRA

RSVP Thurs 25th March
Annabelle Guest
drycotresassoc@gmail.com
or text 0428 924 568