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SUMMER SCHOLARSHIP REPORT

Water use efficiency, gross margin, yield and quality of 1 m and 1.5 m row irrigated cotton

Mr Timothy Bartimote
A/Prof Daniel Tan and Dr. Rose Brodrick

1. Executive summary:

The past decade has seen a major improvement in cotton Water Use Efficiency (WUE) in Australia. This improvement has been off the back of continual years of low water availability across our major cotton growing regions. Water is the limiting factor in cotton production. Now more than ever, more crop (yield) is needed per drop of water (Roth et al. 2012).

In the previous cotton season (2013-14) rainfall was minimal and allocations were low. This has continued through to the current season with major producers such as Auscott Warren receiving 50% of their regular allocations. Lower than average rainfall during the winter has meant our catchments and dams are not being refilled as quickly. Driven by necessity, more research into water use efficiency is being done as cotton used 256 Gm^3 worldwide between 1997 and 2001 (Chapagain et al. 2006; Tennakoon and Milroy 2003).

This experiment aims to determine the effect that 1 m (conventional) and 1.5 m (wide) row spacings have on WUE, yield, cotton quality and economic efficiency. The field experiment is being conducted at Auscott Limited near Warren. This site is representative of irrigated cotton production in semi-arid areas where water is the most limiting factor of production.

Harvest has not yet occurred and is proposed to begin around the 20th April 2015. Hence the data from this experiment are not yet available. When the collection of all the required data is complete, it will be presented as part of my thesis. This will be submitted as my final report. I have included methodologies and potential future research options.

2. Background:

Row spacing in cotton is an important factor that can influence yield; water availability and plant vigour in a crop (see Figure 1). There are many options to choose from but most Australian cotton is grown on conventional systems (1 m), previously on Ultra Narrow Row (UNR) (< 0.4 m) and recently wide row systems (1.5 m) along with some variations (Roche et al. 2006). Compared with UNR and conventional spacing, less is known about wide 1.5 m spacing.

Figure 1: Example of the difference in plant vigour and boll count of two cotton plants with different row spacing. Left: 1.5 m Right: 1 m

Compaction of subsoil and the creation of hardpans increases soil strength and decreases overall soil fertility by limiting supply of water and nutrients (Hamza and Anderson 2005). Controlled Traffic

Farming (CTF) involves minimising the area affected to small regularly spaced strips. In Australian cotton systems, UNR and wide rows allow for 100% Controlled Traffic Farming (CTF) regimes to be installed to minimise compaction. This system allows implements with a multitude of widths to travel on the same 3 m wheel tracks. Wider wheel tracks minimise the traffic whereas conventional 1 m row spacing are limited to 2 m wheel tracks as a 3 m wheel track would mean that machinery would have wheels on a hill and a furrow (Masek et al. 2010).

It is theorised that wide row systems can also provide an increase in irrigation water use efficiency. Cotton in a wide row would have a larger "bucket" to draw water from and hence, require fewer waterings. When rainfall occurs there is also a wider area for rainfall capture. Due to these wider rows there would also be fewer plants per hectare. A lower plant density may require less water per irrigation than to appropriately water the same sized field sown with cotton with 1 m spacing. This would be most beneficial in seasons where there is infrequent summer rainfall as the extra water that each plant receives would translate into longer irrigation cycles, i.e. twelve as opposed to eight days between waterings. The ultimate aim is to grow more cotton in 1.5 m rows than 1 m spaced cotton with the same amount of water i.e. to maximise water use efficiency under a water-limited semi-arid environment.

Land is no longer the most limiting factor in cotton production, yet that is how yield efficiency (bales/ha) is traditionally expressed. In this project I propose that cotton yield should be expressed over the most limiting input to production in irrigated systems, which is water (Roth et al. 2012). As an industry, if opportunities can be developed to increase bales (227 kg/bale) per mega litre, then growers are ultimately becoming more efficient and more resourceful in reducing their bottom line.

3. Aims and objectives:

Figure 2: Wide row (1.5 m) (left) and conventional (1 m) (right) row spacing in the randomised complete block design experiment located at Auscott Warren.

My research aims to provide accurate and reliable data to allow cotton producers to make informed decisions regarding potential management practices to do with row spacing in cotton (see Figure 2). It will provide information regarding yield, water use efficiency, plant mapping and economic analysis of the two row configuration systems. Finally, this experiment will test the hypothesis that growing cotton on 1.5 m row spacing will increase cotton water use efficiency compared with 1.0 m row spacing at Auscott Warren where water is particularly limiting.

This project aims to:

- Compare water use efficiency (bales/ML) between wide row (1.5 m) and conventional (1.0 m) cotton systems. Particularly with the use of "green" water such as rainfall and deep soil moisture;
- Conduct a detailed gross margin and economic analysis; and
- Investigate if there is a difference in yield and fibre quality between conventional and wide row cotton systems.

It will build on the work of Richard Quigley who worked mainly on comparing cotton yield/ha between the two row systems, by providing a second year of data enabling a more complete picture of the differences in yield, water use efficiency and gross margins between conventional and wide row cotton systems.

4. Materials and Methods:

A randomised complete block design with ten replicates of each treatment was used for 1.5 m and 1 m wide rows at the commercial cotton farm at Auscott Warren (see Table 1). This was situated on a 17.556 ha block.

Table 1: Experimental design and row configuration for row spacing experiment in 2014-15 – wide row and conventional row. Total size of field is 17.556 ha with each row 770 m long. Blocks are 12 m in width with a 24 m of buffer wide row cotton on the southern edge.

Treatment	Replicate	AB line	Description		METERS	PROG.m
B		0			12	12
B		1	X	24m buffer	12	24
A	1	2			12	36
A	2	3			12	48
B	1	4	X		12	60
A	3	5			12	72
A	4	6			12	84
B	2	7	X		12	96
B	3	8			12	108
A	5	9			12	120
B	4	10	X		12	132
A	6	11			12	144
B	5	12			12	156
B	6	13	X		12	168
A	7	14			12	180
A	8	15			12	192
B	7	16	X		12	204
A	9	17			12	216
A	10	18			12	228
B	9	19	X		12	240
B		20			12	252

A = conventional row spacing (1 m) (2m tractor)

B = wide row spacing (1.5 m) (3 m tractor)

X = spray tracks

N ↓

Water balance - To determine water use efficiency for both treatments, a water balance model will be calculated from field measurements to compare the amount of water used in each treatment.

Figure 3: Capacitance probe installed in the experimental field.

The field was fully irrigated, with mace meters stationed at the inlet and outlet to measure water added to and taken away from each plot. Capacitance probes were installed to monitor soil water content throughout the season (see Figure 3).

Water balance will be determined by estimating water added to and taken away from each treatment plot. Initial moisture levels were calculated using gravimetric analysis. It involved taking soil cores and determining the water content from the samples every 10 cm down the profile (to 90 cm). The difference between soil wet weight and oven dry-weight provided this information.

An automatic weather station including a rain gauge will measure daily rainfall and temperature and will be incorporated into the water balance model. Deep drainage and watering efficiency during irrigation will be analysed through SIRMOD, a water tracking software program. An Irrimate siphon flow meter was used to determine velocity and quantity of water applied during an irrigation. In conjunction with advanced sensors down the field, water infiltration will be calculated and hence, water lost to deep drainage. Another gravimetric measurement at the end of the season will determine final soil moisture. A CSIRO web based tool, IrriSAT will be used to estimate crop evapotranspiration using a calibrated crop coefficient approach.

Once the water balance model is completed and the cotton is harvested, a final conclusion can be reached as to which treatment is the most water efficient. A comparison in bales/ML, which includes water that was applied directly by irrigation or naturally through rainfall, will achieve this aim. Genstat v16, a statistical program will be used for analysis of variance to detect differences between the treatments.

Plant mapping and soil properties - Plant mapping has been conducted on randomly selected rows of each treatment. This includes nodes above white flower (NAWF), number of nodes and exact boll counts. Particle size analysis (PSA) on soil samples down to 90 cm in depth will provide information regarding the soil texture properties and how this may affect plant growth of the two row configurations.

Yield and fibre quality - At harvest maturity, yield components will be determined through segmented picking and mechanical harvesting. Segmented picking involves recording the position of different cohorts of fruit by handpicking cotton for 1 m on random rows from each treatment. This will provide information regarding fruit positioning and the distribution of yield on 1.5 m and 1.0 m row cotton.

Fibre quality of the picked cotton will be determined using these segment picked samples. After ginning, the samples will be classed using a High Volume Instrument (HVI) which will be used to measure fibre length, strength, colour and micronaire.

Economics - A detailed gross margin and economic analysis will also be conducted comparing the different row spacings. This will be accomplished with the help of Sydney University Economist A/Prof Tiho Ancev. I aim to provide growers with better data and information.

5. Results:

Currently I am still waiting to compile the water balance data. This includes the final gravimetric analysis to determine end soil moisture, the total rainfall for the whole season and the mace meter readings.

Harvest has not yet occurred (projected to be around 20th of April) and this will provide the yield, cotton quality, economic analysis and water use efficiency data.

I will submit my thesis as my final report in November 2015 which will include all data and analyses from this experiment.

6. Discussion and conclusions:

No conclusions or further discussion points can be made at this stage.

7. Highlights:

A longer water cycle of four days was observed in the wide row cotton compared with the conventional rows. This was mid-season and thought to be attributed to the reduced cotton plant density per hectare.

Further highlights may be more apparent when final data have been compiled and analysed. This will be presented in my thesis.

8. Future research:

Water efficiency has improved dramatically over the past few decades and there is no reason why we cannot aim to further improve water use. This research is an example of how specific management practices in cotton production can be fine-tuned to enable higher water efficiency overall.

The comparison between wide row (1.5 m) and conventional row (1 m) in an irrigated system can open pathways to compare the potential row spacings in dryland cotton systems. I had the opportunity to meet farmers in the Liverpool Plains who are doing exactly that. One was even comparing conventional and wide row in his cotton operation.

Watering cycles are an important part of irrigated cotton. Too many days between waterings can lead to extreme water stress and affect plant growth and yield. Too few days and water could potentially be wasted and even cause water logging. Research could be done to determine if there is a point at which yield is affected due to water stress sustained during the season. The question being: How much water stress can be sustained before yield is affected significantly? This could be part of research currently being conducted using thermal infrared imaging to determine water stress and optimal water cycles (Conaty *et al.* 2012; Meron *et al*. 2013).

9. Presentations and public relations:

In early October 2015 my thesis will be presented in the form of a poster. This is part of the assessment requirement in the thesis component. A copy of my thesis will be presented to staff members in the Agriculture and Environment faculty of the University of Sydney for review.

8th-10th September 2015 – I intend to present my work at the Australian Cotton Research Conference in Toowoomba.

10. Reference List:

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