Toward better water management of Bollgard II cotton

By Steve Yeates[1], Jenny Roberts[1], James Neilsen[1] and Dirk Richards[1]

The release of Bollgard II cotton varieties has required efficient water management of a plant that can produce very high yields combined with a main stem that is rarely tipped by insects and has a very high fruit retention. So a high boll load early in flowering can lead to premature cutout and lower yields.

The aim of our research was to tailor irrigation scheduling that could combine soil and plant based measurements of plant stress to optimise the yield and water use efficiency of these high retention varieties. Summarised is research on furrow irrigated cotton in large scale plots over the past three seasons on a cracking clay soil with 200 mm of available water.

Key results to date

- Don't stress Bollgard II from peak flower to cut-out as it is more sensitive to stress than conventional. The lint yield reduction at cut-out equates to a loss of 2.7 per cent per day of stress compared to 1.2 per cent per day for the conventional variety. A much higher boll load at the time of stress prevented compensation in the Bollgard II variety.
- The response of Bollgard II to different irrigation frequencies (deficits) was strongly influenced by seasonal conditions. Lint yield was less sensitive to deficit in 2007–08 – a cooler more humid season – and water use efficacy was higher using larger deficits (80 mm). In contrast, in the hot dry season of 2006–07, yield was increased by 20 per cent using a 40 mm deficit compared to an 80 mm deficit and water use efficiency was greater with frequent irrigation.
- Generally Bollgard II produced consistently higher yields (about five bales per acre) at smaller deficits (35 to 54 mm) during flowering. But yield and WUE at a 35 mm deficit was reduced in 2007–08 by rainfall coinciding with irrigation.
- When irrigating at smaller deficits during hot dry weather at flowering, yield was increased via the growth of new fruiting branches and squares. Higher water availability ensured vegetative growth was not suppressed in preference to boll growth as occurred during slight water stress. But in mild humid weather frequent irrigation can produce excessive leaf and stem growth at the expense of bolls.
- Major considerations before using small deficits are the capacity to apply irrigation on time, the efficiency with which this water is applied and the likelihood of water logging due to rainfall, field design or soil constraints. In soils with greater or lower moisture holding capacity, cotton could respond differently to the deficits used here.
- Future Research: Information that can permit scheduling of irrigation that incorporates available soil water and evaporative demand is a key goal. We also hope to gain a better understanding of how partitioning of growth between bolls, leaves and stems interacts with water availability. This knowledge could be used in the future to balance growth using water.

THE SENSITIVITY TO MOISTURE STRESS OF BOLLARD II COMPARED WITH CONVENTIONAL COTTON

METHODS

Three replicated experiments were conducted, using furrow irrigation at ACRI, Myall Vale in 2004–05, 2005–06 and 2006–07. The Varieties Sicot 71 and Sicot 71BR were compared. Irrigation was

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Replicated paddock length experiments have been used to measure the water balance and crop response to irrigation scheduling.

Varying the soil water deficit in response to plant stress could capture more rainfall and reduce irrigation water requirement. Warren Conaty (PhD Student, University of Sydney, CRC Irrigation Futures and Cotton Catchment Communities CRC) is evaluating inexpensive BIOTIC sensors (Biologically Identified Optimal Temperature Interactive Console) as an irrigation tool which utilises infra-red thermometers to calculate canopy temperature to determine the necessity of irrigation.

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scheduled at extraction of 40 per cent of plant available moisture content (PAWC) of the soil or an 80 mm deficit for a soil with 200 mm of available water.

Water stress was applied at first flower, cut-out (NAWF lower than 4.5) and at peak flower (10 to 14 days after first flower) by skipping irrigation at each growth stage. Soil water was measured using a neutron probe.

The volume of irrigation applied and tail water run off was measured in each plot using odyssey probes in the channel and rotorbuck and in a flume 20 metres from the tail drain.

KEY RESULTS

The effect of water stress on relative yield

Table 1 summarises the percentage yield reductions due to water stress between first flower and cut-out. Bollgard II was more sensitive to stress than conventional at peak flower and cut-out. The lint yield reduction at cut-out equates to a loss of 2.7 per cent per day of stress compared to 1.2 per cent per day for the conventional variety.

Fibre quality differences

Fibre length of Bollgard II was reduced by 0.04" when stressed at cut-out and 0.01 to 0.03" when stressed at mid flowering. The effect of this moisture stress on micronaire was inconsistent and less severe for Bollgard II than for the conventional variety.

THE RESPONSE OF BOLLGARD TO IRRIGATION AT DIFFERENT DEFICITS – A TALE OF TWO SEASONS

The aim was to compare four irrigation deficits 40, 60, 80 and 120 mm which equates to 20, 30, 40 and 60 per cent of PAWC (plant available water content) for a soil with 200 mm of plant available water and to measure the plant response to these deficits.

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TABLE 1: Yield loss due to water stress (extraction of more than 60 per cent plant available water)

Growth stage of Bollgard II	Average % yield loss 2005 to 2007 where there was no significant rain	
	Bollgard II	Conventional
1st Flower	23%	23%
Cutout	36%	17%

TABLE 2: Effect of deficit on yield (b/ha) from squares present at 1st flower (1 flower/m) and yield on squares grown after first flower

2006–07			2007–08		
Deficit (mm)	Yield from squares at 1st flower	Yield from squares set after 1st flower	Deficit (mm)	Yield from squares at 1st flower	Yield from squares set after 1st flower
39	6.3	6.0	35	5.7	7.3
68	6.3	4.4	54	6.4	7.4
82	6.3	4.2	78	5.9	6.7
124	4.2	1.9	126	6.2	5.8

FIGURE 1: Cumulative potential evapotranspiration (ETo) for each growth phase calculated using FAO 56

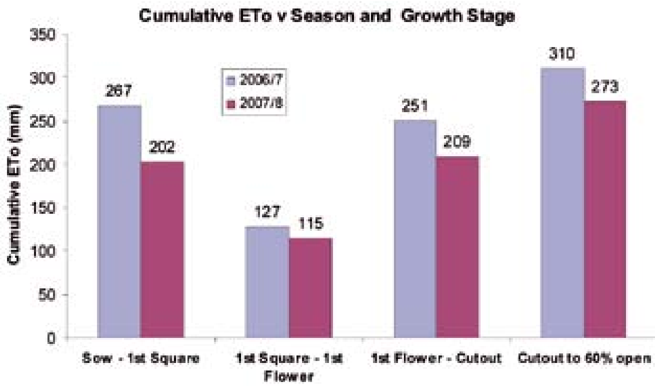
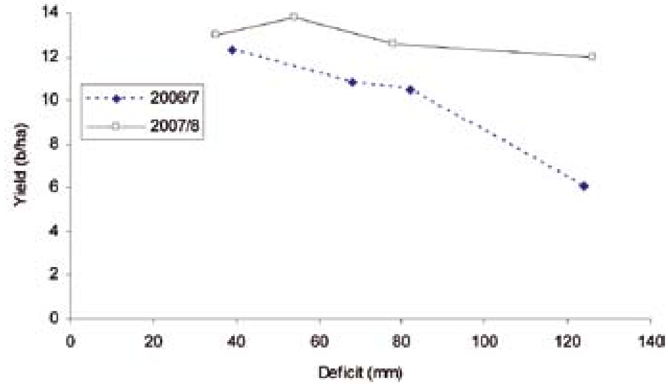


FIGURE 2: The effect of deficit on lint yield



The deficit is calculated from early flowering to late February. Prior to flowering irrigation was scheduled at a similar PAWC to shown above. Where lsd = 1.2 and 0.67 b/ha for 2006–07 and 2007–08.

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METHODS

Two replicated experiments were conducted, using furrow irrigation at ACRI, Myall Vale in 2006–07 2007–08. Plot size was length of the field by 12 to 20 rows. The variety Sicot 71BR was sown in 2006–07. In 2007–08 Sicot 70BRF was sown with a 30 metres sub plot of Sicot 71BR in the 40 and 60 mm treatments. Soil water was measured using a neutron probe.

KEY RESULTS

Seasonal conditions

Climatically the 2007–08 season was more favourable for cotton growth than 2006–07. The 2006–07 season had less in crop rainfall (188 mm) compared with 368 mm in 2007–08 and temperatures were cooler in 2007–08. But despite cloudy days, the cumulative solar radiation was very similar for the two seasons. Figure 1 shows daily potential evapotranspiration (ETo) summed for each growth phase. ETo gives an indication of evaporative demand and can be used to predict crop water use. Evaporative demand was clearly higher in 2006–07 with ETo total-

TABLE 3: The effect of deficit on fibre quality (for Sicot 70BRF in 2007–08 and Sicot 71BR in 2006–07 and 2007–08 in brackets)

Season	Deficit	Length	Strength	Micronaire
2006–07	39	1.17	30.6	5.0
	68	1.15	29.7	5.2
	82	1.16	29.6	5.4
	124	1.11	28.6	5.6
	$lsd_{0.05}$	0.022	1.45	0.198
2007–08	35	1.20 (1.17)	29.5 (28.7)	4.0 (4.4)
	54	1.21 (1.17)	29.9 (29.5)	3.7 (3.9)
	79	1.22	30.3	3.9
	126	1.20	30.1	4.1
	$lsd_{0.05}$	0.023	1.01	0.199

Left: Increased water availability during flowering reduced plant stress and increased yield via the production of more squares during flowering which became bolls near the top and on the outside of the plant. Centre: Stress during flowering suppressed the production of new squares and the plant filled the existing bolls. Right: Large boll on top of plant.

ling 955 mm compared with 799 mm for the 2007–08 season.

Lint yields and fibre quality

The deficits achieved at maximum soil water extraction are shown in Figure 2 with their yields. The yields were significantly different in both seasons as was the response to deficit. Lint yield was less sensitive to deficit in 2007–08 when evaporative demand was lower.

The lint yield when irrigating at a 39 mm deficit in 2007–08 was significantly lower than for the 58 mm deficit and could be attributed to slight water logging as rain coincided with irrigation on five of the 10 irrigation events.

It is also clear the yield of Bollgard II responded to frequent irrigation when evaporative demand is high as occurred in 2006–07.

The increase in yield from irrigating at smaller deficits during flowering came from fruiting sites grown after flowering (Table 2). That is, P1 and P2 bolls nearer the top of the plant and vegetative branch bolls. So for Bollgard II plants, balanced growth was achieved because higher water availability ensured vegetative growth was not suppressed in preference to boll growth as would occur during water stress.

Deficit significantly affected fibre quality parameters in both seasons (Table 3). In 2006–07 only the largest deficit (124 mm) impacted on length and strength. Micronaire increased as deficit increased and may be explained by high boll loads as water availability increased. In 2007–08 only micronaire was reduced using a 54 mm deficit.

FUTURE WORK

Information that can permit scheduling of irrigation that incorporates available soil water and evaporative demand is a key goal. We also hope to gain a better understanding of how partitioning of growth between bolls, leaves and stems interacts with water availability.

This knowledge could be used in the future to balance growth using water. This experiment has been repeated in 2008–09 and water balances for the three seasons will be calculated in the near future.

The assistance of Dr Greg Constable, Des Magan, Michael Price and Paul Williams in designing and managing these experiments was greatly appreciated. The Cotton Research and Development Corporation and Cotton Catchment Communities CRC provided partial funding support for this research.

[1]CSIRO Plant Industry, ACRI, Narrabri and Cotton Catchment Communities CRC.

Longacres gas conversion

By Stuart Bray[1]

The irrigation farm 'Longacres' on the banks of the Mooki, near Gunnedah, is in the process of converting their engines from diesel to diesel-gas. Its under trial now on one of their pumping engines. The manager, Tim Leo, said if it works out he will incorporate gas substitution to another five pumps.

Elgas supplies the gas to the farm, and then it is mixed with the diesel on site into the six cylinder turbo charged Perkins Phaser diesel. Although the price of diesel has dropped dramatically in the past six months, farmers are sceptical that it will stay at these levels for long. People like Tim Leo believe to make profits in today's climate they need to look at ways of reducing costs.

Diesel substitution is one way of doing this. By mixing small amounts of liquid petroleum gas with the diesel, the motor runs more efficiently. DieselGas Technologies, who do the conversions, suggest that the burn rate goes from 75 per cent to 98 per cent, while the motor runs better and needs less diesel to maintain its load. The reduction in diesel costs is around 30 per cent. This is acceptable now, but even more enticing when diesel revisits the 170 cents a litre level.

Tim Leo regards his ground water as a precious resource, and because it's the most expensive water to use, is always pumped last and sparingly with the most efficient use of energy to get it above ground. This is the reason for the interest in diesel substitution and/or any other system that will reduce pumping costs.

There are always expenses to improve a situation, and the conversion that needs to be done to the motor at current costs is approximately $9000 depending on the degree of difficulty with the conversion. The savings can be paid back in one season on a 300 HP motor according to Matt Derrig, director of DieselGas Technologies.

DieselGas Technologies have completed 40 gas conversions in northwest NSW during the last two years. This was during the peak of the fuel crisis. But farmers and businesses are still concerned that once the economic crisis is over, fuel prices will soar again. At conversion, the motor is given a full assessment to check that it is running at the correct speed. Several cases have occurred where the motor was over worked and adjusted to optimise its performance. In some cases this has increased fuel efficiency by up to 50 per cent.

High fuel prices are not the only reason companies are converting to diesel-gas. Large corporations are looking at the conversion as a way of minimising their carbon footprint. Nitrous oxide or NOx is a targeted emission and it can be reduced by up to 20 per cent through this process.

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Matt Derrig, Director DieselGas Technologies, conducting a gas conversion at 'Longacres' Gunnedah.