Toward better water management of Bollgard II cotton

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Key Points

- When comparing BollgardII with conventional cotton, the lower water requirement and higher lint yield of Bollgard II was explained by greater insect damage in conventional cotton. The effect of this damage was to delay time to maturity and increase leaf area of the conventional variety, which in turn increased crop water use. In situations where pest damage is minimal, variety differences are unlikely or could favour the conventional variety where tipping is the only damage.
- Water stress equivalent to extraction of > 60% of plant available water at mid flowering and cut-out reduced Bollgard II yields by 24 and 36%, compared with 2 and 17% in conventional. A much higher boll load at the time of stress prevented compensation in the BollgardII variety.
- Over 2 seasons the response of BollgardII to different irrigation frequencies (deficits) was strongly influenced by evaporative demand. Where the deficit was about 80mm (40% of PAWC) yield was increased by 20% in the lower evaporative demand season. The yield difference was minimal with a deficit < 40mm (20% of PAWC).
- Generally Bollgard II produced consistently higher yields at smaller deficits (35 to 54mm). However yield at a 35 mm deficit was reduced in 2007 / 08 by rainfall coinciding with irrigation.

Introduction

The general aim of our research is to develop principles of irrigation scheduling through agronomy and physiology research to optimise Bollgard II performance in all production regions. Our work is linked to James Neilson's research at the plant level and the improvement of farm scale support tools like HydroLOGIC.

Last Cotton Conference we reported on field scale experiments using furrow irrigation measure the sensitivity of Bollgard II compared with its conventional equivalent variety to water stress at different growth stages (see Yeates et al 2006). We also reported the results of replicated experiments to measure the water requirement of Bollgard II compared with conventional cotton when fully irrigated at deficits commonly used for conventional cotton (see Richards et al 2006). These experiments were conducted over two seasons at ACRI Myall Vale, with a third season planned for the 2006 / 2007 cotton season. This paper reports the outcomes of the three seasons of experimentation.

The second part of this paper describes experiments conducted over the last two cotton seasons that aim to determine wether a different soil water deficit to that used for conventional cotton is required to optimise production and water use efficiency of Bollgard II cotton.

1. The irrigation water requirement and sensitivity to moisture stress of Bollard II with conventional cotton.

Methods

Three replicated experiments were conducted, using furrow irrigation at ACRI, Myall Vale in 2004 / 5, 2005/6 and 2006/7. The Varieties Sicot 71 and Sicot 71BR were compared. Irrigation was scheduled at extraction of 40% of plant available moisture content (PAWC) of the soil or an 80mm deficit for a soil with 200mm of available water. Water stress was applied by at first flower, cut-out (NAWF < 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 20m from the tail drain.

Key Results

Irrigation water requirement.

The irrigation water applied is shown in Table 1. Averaged over three years Bollgard II required 0.5 less ML ha of irrigation water than conventional cotton. The average lint yield was 10.1 and 9.2 b/ha for Bollgard II and conventional respectively. The difference in water requirement and lint yield between the varieties was explained by greater insect damage in conventional cotton. Prior to flowering caterpillar pests tipped the main stem on the conventional variety 5 to 20 times more frequently than in Bollgard II. Fruit retention was also significantly reduced by these pests in the conventional variety. The effect of this damage was to delay time to maturity and increase leaf area of the conventional variety, which inturn increased crop water use. An additional irrigation was required in 2004 / 2005 (Table 1).

Table 1: Total irrigation water applied (ML/ha).

Season	Sicot 71BR	Sicot 71
2004 / 2005	**6.9**	**7.8**
2005 / 2006	**5.7**	**6.1**
2006 / 2007	**6.3**	**6.5**
Average	**6.3**	**6.8**

The effect of water stress on relative yield.

Table 2 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 day of stress compared to 1.2% per day for the conventional variety.

Table 2: Yield loss due to water stress (extraction of > 60% plant available water)

Growth Stage of BG	Average % yield loss 2005 to 2007 where there was no significant rain	
	Bollgard ®II	Conventional
1st Flower	23%	23%
Peak Flower	24%	2%
Cutout	36%	17%

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.

2. 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 % of PAWC for a soil with 200mm of plant available water.

Methods

Two replicated experiments were conducted, using furrow irrigation at ACRI, Myall Vale in 2006/7 2007/8. Plot size was length of the field by 12 to 20 rows. The variety Sicot 71BR was sown in 2006/7. In 2007/8 Sicot 70BRF was sown with a 30m 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 2007/8 season was more favourable for cotton growth than 2006/7. Figure 1 shows that 2006/7 had less in crop rainfall (188mm) compared with 368 mm in 2007/8 and temperatures were cooler in 2007/8. However, despite cloudy days, the cumulative solar radiation was very similar for the two seasons. Figure 1 also shows daily potential evpotranspiration (ETo) summed for each growth phase. ETo gives an indication of evaporative demand and can be used to predict cop water use.

Evaporative demand was clearly higher in 2006/7, totalling 955 mm compared with 799 mm for the 2007/8 season.

Lint Yields and Fibre Quality.

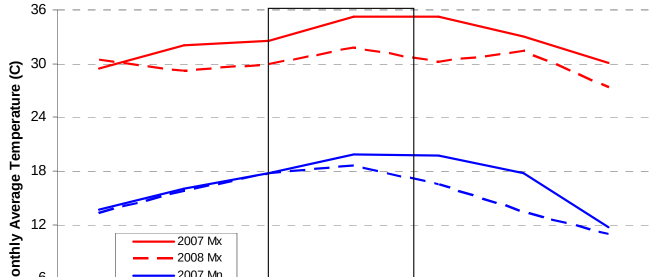
The actual deficits achieved at maximum soil water extraction are shown in Table 3 with their yields. The yields were significantly different in both seasons and the response to deficit was different. Lint yield was less sensitive to deficit in 2007/8 when evaporative demand was lower. The lint yield when irrigating at a 39mm deficit in 2007/8 was significantly lower than for the 58 mm deficit and could be attributed to slight water logging as rain coincided with irrigation on 5 of the 10 irrigation events. It is also clear that Bollgard II responded to frequent irrigation when evaporative demand is high as occurred in 2006/7.

Deficit significantly affected fibre quality parameters in both seasons (Table 4). In 2006/07 only the largest deficit (124mm) 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 54mm deficit.

General Discussion

When comparing Bollgard II with conventional cotton, the lower water requirement and higher lint yield of Bollgard II was explained by greater insect damage in conventional cotton. The effect of this damage was to delay time to maturity and increase leaf area of the conventional variety, which in turn increased crop water use. In concurrent trials at Keytah near Moree where the percent tipping was high but the insect damage to fruit was minimal on the conventional variety it produced a greater yield and water use efficiency than the Bollgard II variety. A much higher boll load at the time of stress prevented compensation in the Bollgard II variety hence the greater yield reductions during boll growth.

The response of Bollgard II to different irrigation frequencies (deficits) appeared to be influenced by evaporative demand. In 2006/7 when evaporative demand was high yield was about 2b/ha lower at larger deficits. The effect of evaporative demand was minimised using smaller deficits (40mm) Generally Bollgard II produced consistently higher yields at smaller deficits (35 to 54mm). However yield at a 35 mm deficit was reduced in 2007 / 08 by rainfall coinciding with irrigation



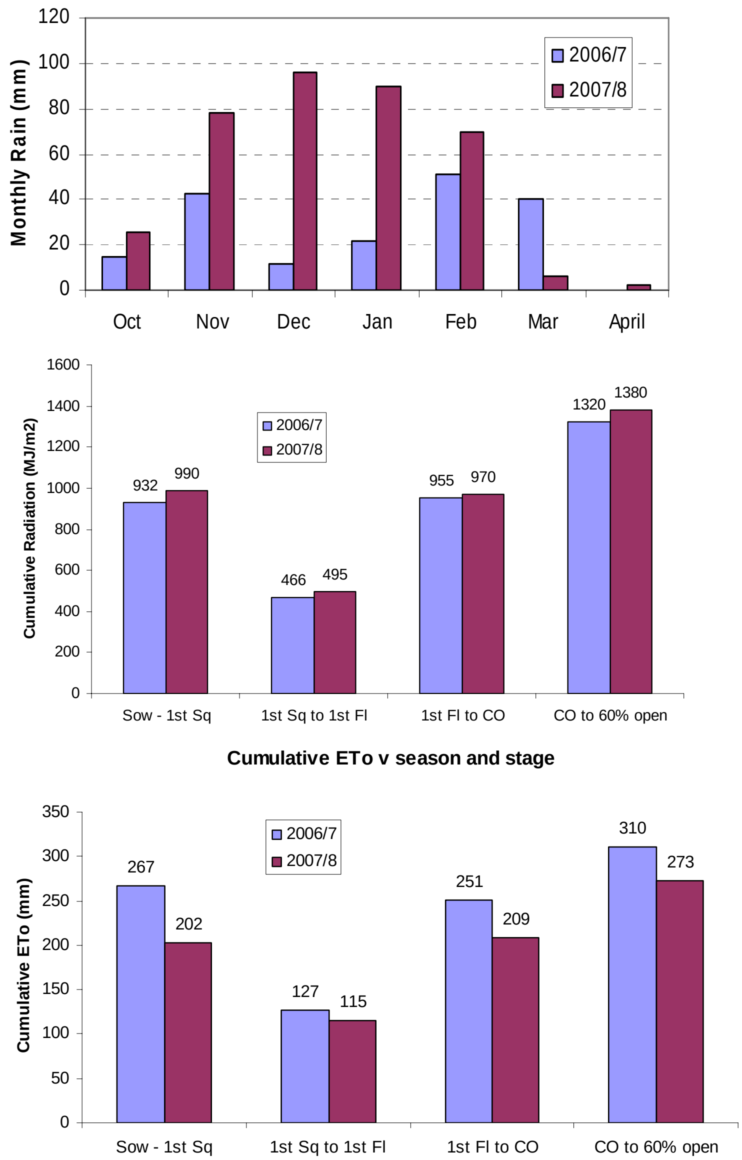


Fig. 1: Average monthly temperature, rainfall, solar radiation accumulated between each growth stage and cumulative potential evapotranspiration (ETo) for each growth phase calculated using FAO 56.The box on the temperature averages marks the flowering period.

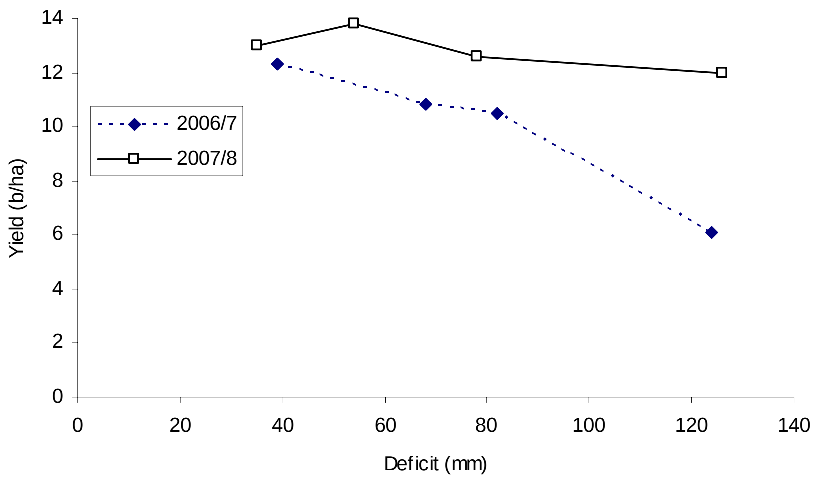


Figure 5: The effect of deficit on lint yield. The deficit is calculated from early flowering to late February. Prior to flowering irrigation was scheduled at a similar PAWC to shown above. Where lsd 1.2 and 0.67 b/ha for 2006/7 and 2007/8.

Table 3: The effect of deficit on fibre quality. For Sicot 70BRF in 2007/8 and Sicot 71BR in 2006/7 and 2007/8 in brackets.

Season	Deficit	Length	Strength	Micronaire
	39	1.17	30.6	5.0
2006/7	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
	35	1.20 (1.17)	29.5 (28.7)	4.0 (4.4)
2007/8	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

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 will be repeated for a further season and water balances for the three seasons calculated.

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