

Progress in evaluating the moisture stress response of Bollgard II[®] compared with conventional cotton

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Key Points

- Bollgard[®]II accumulated yield faster than conventional cotton due to higher retention combined with a very low proportion of tipped plants. This meant that late in flowering and at cut-out Bollgard[®]II was less able to compensate for water stress equal to a depletion of ≥ 120 mm of soil water ($\geq 58\%$ plant available soil water) and yields were lower relative to conventional cotton stressed at the same time.
- Yields and soil water extraction of Bollgard[®]II and conventional cotton were the same when moisture stress occurred at early flowering.
- With full irrigation, that is soil water deficits of 44 to 83 mm, Bollgard[®]II had the same yield or higher yield than conventional cotton but matured earlier due to more rapid boll setting.
- Future research will aim to optimise irrigation scheduling of Bollgard[®]II for yield and water use efficiency.

Introduction

Prior to introduction of Bollgard[®]II varieties there was a concern that the water requirements and irrigation scheduling may differ from conventional varieties. One hypothesis was that a Bollgard[®]II plant with higher early fruit load and less likelihood of tipping, might be smaller at the start of flowering and might have a smaller root system during the peak flowering and boll filling period. If that was true, Bollgard[®]II may require a different irrigation schedule.

Experiments were initiated to clarify and quantify any differences in plant water demand between conventional and Bollgard[®]II varieties, and to begin formulating management guidelines if required. We describe in this paper progress with the following objectives:

- Determining the sensitivity of Bollgard[®]II to soil moisture stress at different plant development stages.
- Relating fruit retention patterns to plant water extraction and yield.

The irrigation water use efficiency of Bollgard[®]II and conventional cotton is presented in an accompanying paper (Richards et al., these proceedings).

Methods

Two experiments were conducted, using furrow irrigation at ACRI, Myall Vale in 2004 / 2005 and 2005 / 2006. The Bollgard[®]II variety Sicot 71BR and its conventional equivalent were planted on the 25-26th October 2004 and 3-4th October 2005 with an established plant stand of 12-14 plants / m of

row. There were 3 replications of each irrigation treatment for each variety. Plot size was 24 rows by the length of the field, which, was 600m in 04/05 and 500m in 05/06. Insect pest management decisions were made using CottonLOGIC thresholds for each variety. Full irrigation was compared with skipping the first, second and third irrigations. In 05/06 an additional treatment of skipping the final 2 irrigations was included (Table 1).

Table 1: Irrigation treatments (NT = not tested)

Treatments	Date when irrigation skipped	
	2004 / 2005	2005 / 2006
Full irrigation	None	None
Skip 1 st irrigation	6-Jan	29-Dec
Skip 2 nd irrigation	21-Jan	9-Jan
Skip 3 rd irrigation	4-Feb	27-Jan
Skip final 2 irrigations	NT	8-Feb and 6-March

Results

Tipping and fruit retention

The most obvious early season difference was the greater main-stem tipping and lower total fruit retention of conventional cotton. At first flower tipping of the conventional variety was 5 to 20 times more frequent than in Bollgard[®]II. Fruit retention (all sites) at first flower was 89% in Bollgard[®]II compared with 62% in conventional cotton. Hence, boll numbers and boll weight increased at a faster rate in Bollgard II[®], resulting in earlier maturity.

Growth stage and relative boll load at time of water stress.

Water stress at the first and second irrigations coincided with early flowering and mid-flowering in both varieties (Table 2). However, by the third and later irrigations Bollgard[®]II had a higher fruit load and the growth stages were different (Table 2). The third irrigation coincided with last effective flower or cut-out in Bollgard[®]II and late flowering in the Conventional. In 05/06 the conventional cotton was at cut-out about the time of the fourth irrigation or 12 days later than the Bollgard[®]II. The relative boll number reflected the rapid fruiting in the Bollgard[®]II and after the first irrigation was between 1.3 and 3.2 times that of the conventional cotton (Table 2).

Soil water deficits and relative yield.

In both seasons there was no difference in soil water extraction between the varieties up to cut-out in Bollgard[®]II 04/05 and up to 14 days after first flowering in 05/06 (Table 3). In 05/06 there was greater soil water extraction by the conventional during the cut-out stress due to a greater leaf area.

Where no irrigation was made post cut-out in 05/06, the Bollgard[®]II extracted more soil water with a higher yield than the conventional. This yield difference was to the Bollgard[®]II being at a later stage of development when the irrigations were skipped, so it required less water to complete growth.

Table 2: Details of crop growth stage and relative boll number of Bollgard® II (BG) compared with Conventional (Con) when water stress was imposed. The rainfall during stress periods is also shown.

	Irrigation Skipped				
		First	Second	Third	Fourth and Fifth
Growth Stage	04/05	1 st Flower	Early Flowering	Cut-out BG	–
	05/06	Early flowering	Mid flower	Cut-out BG	Boll fill
Relative Boll No. (BG/Con)	04/05	1.0	3.2	3.1	–
	05/06	2.4	1.3	1.5	1.4
Rain during stress (mm)	04/05	6.4	41	46	-
	05/06	0	48	65	102

There were four consistent trends in relative yields shown in Table 3:

1. Under full irrigation the Bollgard® II yield was greater than the conventional.
2. Water stress at first flower did not affect yield of Bollgard® II compared with the conventional.
3. When the third irrigation was skipped at cut-out of the Bollgard® II yield was much lower than the conventional (83%). It seems the conventional was able to compensate for the water stress due to it not having completed flowering.
4. Lower relative yields of Bollgard® II at or prior to cut-out were associated with soil water deficits around 120mm or extraction of at least 58% of plant available water.

Table 3: Soil water deficits of stress treatments compared with full irrigation and yield of Bollgard® II relative to conventional for each stress treatment. NB the plant available soil water was measured as 207mm to 120cm.

Timing of water stress	2004 / 2005			2005 / 2006		
	Soil Water Deficit (mm)		Relative Yield (BG/Con %)	Soil Water Deficit (mm)		Relative Yield (BG/Con %)
	BollgardII®	Conventional		BollgardII®	Conventional	
Full Irrigation#	44	50	104	83	78	112
First Flower	79	77	99	104	113	115
Mid Flower	94	91	103	126	120	89
Cut-out*	121	118	83	121	145	82
Skip last 2 irrigations	–	–	–	187	165	108

Soil water deficit is average of irrigations skipped * Bollgard NAWF < 4.5, Conventional NAWF > 5.4.

Lint Yield.

The lint yields for each treatment are shown in Fig. 1. Lint yield of Bollgard®II was the more variable than conventional being the highest when fully irrigated and the lowest when stressed at cut-out. The significantly lower yield in the fully irrigated conventional in 05/06 was due to *Helicoverpa* caterpillars that could not be sprayed for a 10 day period during mid-January due to poor weather. In both seasons Bollgard®II was most sensitive to water stress at cut-out.

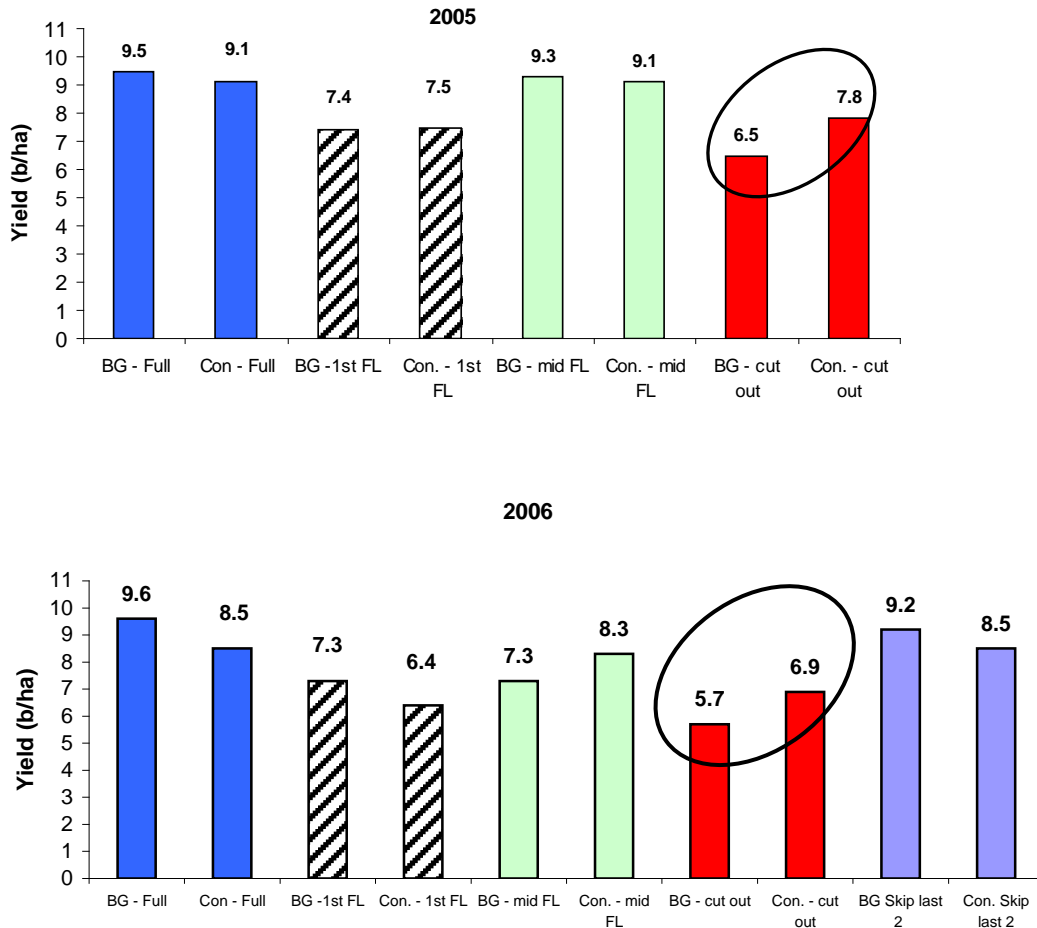


Fig. 1: Machine picked lint yields for different stress treatments. Where $lsd_{0.05}$ 2005 = 0.86, and 2006=0.71. Circled is the yield difference for stress near cut-out for Bollgard II®.

Fibre quality differences.

In 04/05 significant differences were found for fibre length and micronaire (Table 4). Stress at or near cut-out significantly reduced fibre length, while earlier stress had no effect. The conventional cotton had lower micronaire than Bollgard®II with full irrigation and when water stress occurred in early flowering. When stressed late in flowering, micronaire was higher in the conventional and equal to Bollgard II®. The micronaire of Bollgard®II was not affected by moisture stress during flowering or at

cut-out. The difference between the fully irrigated Bollgard[®]II and the conventional for fibre length and micronaire could be partly explained by fibre development occurring under different temperatures, due to later fruiting in the conventional variety.

Table 4: Significant fibre quality differences in 04/05, length and micronaire.

Timing of water stress	Length (in)		Micronaire	
	Bollgard [®] II	Conventional	Bollgard [®] II	Conventional
Full Irrigation	1.140	1.158	4.65	4.33
First Flower	1.143	1.168	4.60	4.53
Mid Flower	1.142	1.167	4.76	4.36
Cut-out	1.113	1.115	4.78	4.76
lsd _{0.05}	0.027		0.27	

Conclusions

- Bollgard[®]II accumulated yield faster than conventional cotton due to higher retention combined with a very low proportion of tipped plants. This meant that late in flowering and at cut-out Bollgard[®]II was less able to compensate for water stress equal to a depletion of ≥ 120 mm of soil water ($\geq 58\%$ plant available soil water) and yields were lower relative to conventional cotton stressed at the same time.
- Bollgard[®]II showed similar sensitivity to water stress in early flowering and soil water extraction was the same as conventional cotton.
- In 04/05 fibre length was only reduced by stress at cut-out, which occurred for Bollgard[®]II and conventional cotton. Micronaire of Bollgard[®]II was not affected by water stress during flowering or cut-out. Although under full irrigation the conventional variety had lower micronaire than Bollgard[®]II.

Acknowledgments

The assistance of Dr Greg Constable, Mr Michael Price and Mr Paul Williams in designing and managing these trials was greatly appreciated. The Cotton Research and Development Corporation and Cotton Catchment Communities CRC provided partial funding support for this research. Support from Monsanto is also acknowledged.