Impact of row configuration on high fruit retention (transgenic) rain-fed cotton systems

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Abstract

Rain-fed cotton is often grown in modified row configurations using skipped rows because of variable summer rainfall. Skip configurations are used to: increase the amount of soil-water available for the crop, which can influence the potential lint yield; reduce the level of variability or risk associated with production; enhance fibre quality; and reduce input costs. The use of transgenic cotton with improved resistance against insect pests in skip configurations can result in early and higher fruit retention. This has raised concerns that high fruit retention may limit the relative benefits of using skip configurations. The potential for root exploration into the skip may be reduced because of assimilate demands associated with early fruit growth and less time to exploit the skip. Insect resistant Bollgard II? cotton was compared with conventional (non-Bollgard II cotton) grown in three row configurations (solid, single, and double skip) over two seasons. Measurements of yield, crop maturity and fibre quality were taken. Results showed that there were no indications that the response of Bollgard II to row configuration was different to that of conventional cotton. As expected, fibre length was improved using the skip configurations compared with solid. Results suggest that cotton growers should consider skip row configurations with Bollgard II crops in the same manner as conventional cotton when considering potential yield and quality.

Key Words

Cotton, rain-fed, dryland, Bollgard, skip row

Introduction

One of the management techniques that rain-fed (dryland) cotton growers have at their disposal is being able to modify row configuration. Growers can choose to sow their crops using conventional solid row configurations similar to those used in Australian irrigated production, or use configurations that considerably increase row spacing or remove entire rows. The intention behind skip row configurations is to provide slowly available soil water to the planted rows to allow continued growth during dry periods between rainfall events. In practice, however, the benefits lie primarily in: (a) a reduced risk of negative effects of water stress on fibre quality, (b) reduced yield variability, and (c) better economic returns due to production costs being reduced more than the yield relative to solid planted cotton (Bange et al. 2004). Recently, genetically engineered (transgenic) cottons expressing genes from *Bacillis thuringiensis* (Bt) have been made available to cotton growers throughout the world. Bt cotton offers significant potential to reduce pesticide use for the control of major Lepidopteran pests (Fitt 2000). In Australia, cotton growers have access to Bt cotton that contain genes that express the insecticidal proteins Cry1Ac and Cry2Ab. The trade name for these Bt cottons is Bollgard II? and the genes are owned by the Monsanto company. The use of transgenic cotton for pest control in skip configurations can result in early and higher fruit retention through better insect control. Generally, a cotton plant with higher early fruit retention will be smaller with less vegetative growth than a plant with lower retention and may mature earlier. This has raised concerns that high fruit retention may limit the benefits of using skip configurations. Increased assimilate demands associated with early fruit growth may limit the potential for root exploration into the skip and hence reduce the capacity of the plant to utilize moisture in the skip. Also, the time for rain-fed crops to utilise the moisture contained in skip rows may be reduced as Bollgard II crops may mature earlier

This paper presents research designed to explore the impact of high fruit retention Bollgard II on yield and fibre quality of rain-fed cotton grown in different row configurations. Two field experiments grown under rain-fed conditions with varied row configurations and conventional (non-Bollgard) and Bollgard II (high fruit retention) varieties were conducted to ascertain: (i) whether Bollgard II crops differed in yield and fibre quality significantly from conventional cotton, and (ii) whether the response of Bollgard II to row configuration was same as that of the conventional genotype

Methods

Cultural Details

Two field experiments were conducted at Narrabri (30.31?S 149.78?E) Australia in the 2004-2005 and 2005-2006 seasons. Each experiment included the non-Bollgard II[?] variety Sicot 189RR and Bollgard II variety Sicot 289BR. The experiments were grown in three row configurations; solid, single and double skip. The solid configuration is similar to those used in Australian irrigated production, i.e. 1 metre row spacing, while the single skip has every third row blank and double skip has two rows of cotton planted then two rows blank. A randomised complete block design with four replicates was used. Experiment 1 was planted on 10 Nov. 2004 and plots were 6m long by 20 rows wide. Experiment 2 was planted on 25 Oct. 2005 and plots were 12m long by 14 rows wide.

Measurements

Timing of crop maturity (defined as 60% bolls open) was estimated by taking repeated weekly counts of the number of open bolls in $1m^2$ in the centre row of each plot. The lint collected from these samples was kept to calculate final lint yield. Fibre quality measurements on ginned lint samples were performed using a high volume instrument (HVI) to obtain fibre length (decimal inches) and micronaire (a measure of fibre fineness and maturity, no units).

Meteorological data for the experimental period was measured 2 km from the sites at a fully serviced weather station (Figure 1). Statistical analyses ANOVA were conducted using Genstat[?] software.

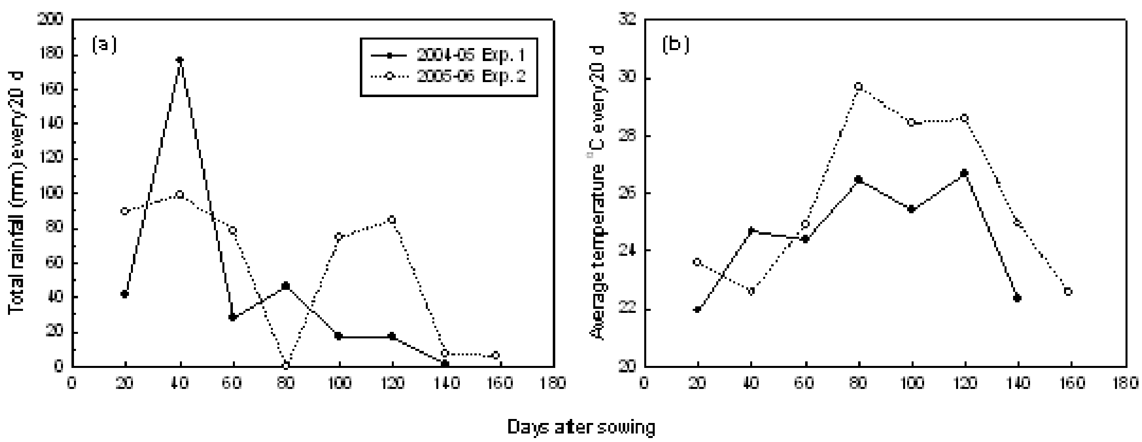

Figure 1. Accumulated rainfall (a) and average temperature (b) experienced every 20 d during both field experiments.

Results

In both experiments there were no significant interactions between configuration and variety for lint yield, maturity or fibre quality (length and micronaire) (Table 1).

In Exp. 1 lint yield was affected by row configuration but not variety. The solid configuration was the highest yielding (mean 87.4 g m^{-2}) which was significantly greater than both the single and double skip configurations which were not significantly different from each other (mean 70.2 g m^{-2}). In Exp. 2 lint yield was not affected by row configuration but was different between varieties: the non Bollgard II variety Sicot 189RR (mean 94.3 g m^{-2}) was significantly greater than Bollgard II variety Sicot 289BR (mean 76.0 g m^{-2}).

Crop maturity was affected by row configuration in both experiments while variety affected maturity only in the Exp. 2. In Exp. 1 solid and single skip were not significantly different (mean 128.8 days after sowing) but were significantly earlier than double skip (mean 133.2). In Exp. 2 double skip (mean 141.1) was again significantly later than solid (mean 133.5) but not different than single skip (mean 139.6). Solid and single skip again were again not significantly different. In this experiment Sicot 189RR (mean 148.8) was significantly later than Sicot 289BR.

The fibre quality attribute micronaire was only significantly different between varieties in Exp 2, with Sicot 189RR (mean 4.9) higher than Sicot 289BR (mean 4.3). Fibre length however, was significantly affected by row configuration in both experiments. In Exp. 1 fibre length of double skip (mean 1.12 inches) was significantly longer than both single skip and solid configuration which were not different from each other (mean 1.08). In Exp. 2 double skip and single skip which were not significantly different from each other (mean 1.15) both had fibre lengths greater than solid (mean 1.11).

Table 1. Yield, fibre quality and crop maturity (defined as the days from sowing to 60% bolls open) for Exp. 1 and Exp. 2 (n.s. no significant difference; * P < 0.05; ** P < 0.01).

Experiment/ Treatment	Lint yield (g m^{-2})	Days after sowing 60% bolls open	Fibre Length (inches)	Micronaire[a]
Experiment 1				
Solid 189RR	91.9	128.5	1.08	4.2
289BR	82.9	127.3	1.08	4.3
Single skip 189RR	69.8	131.3	1.09	4.4
289BR	61.6	128.3	1.09	4.0
Double skip 189RR	67.2	134.8	1.13	3.8
289BR	81.6	131.8	1.11	4.3
Least significant difference				
Configuration	11.4**	3.7*	0.02**	n.s.
Variety	n.s.	n.s.	n.s.	n.s.
Interaction	n.s.	n.s.	n.s.	n.s.

Experiment 2				
Solid 189RR	96.0	147.5	1.12	5.1
289BR	67.6	123.5	1.11	3.9
Single skip 189RR	95.7	149.0	1.14	5.0
289BR	88.3	130.3	1.15	4.4
Double skip 189RR	91.2	150.0	1.17	4.6
289BR	72.2	132.3	1.15	4.6
Least significant difference				
Configuration	n.s.	4.5*	0.02*	n.s.
Variety	12.6**	3.7**	n.s.	0.2**
Interaction	n.s.	n.s.	n.s.	n.s.

[a] Micronaire has no units

Discussion

These experiments examined the performance of transgenic Bollgard II cotton in rain-fed cotton systems. In these studies only in the second experiment did the Bollgard II variety Sicot 289BR yield less than the non-bollgard variety Sicot 189RR. This reduction in yield was most likely associated with earlier and higher fruit load afforded by improved pest control, followed by a significant period of extreme hot and dry weather (days after sowing 60-80; Figure 1) causing the crop to cease production of new fruiting sites (cut-out). Earlier cut-out causes crops to mature earlier and is associated with reductions in yield (Bange and Milroy 2004, Stiller et al. 2004). Earlier maturity was measured in the Bollgard II treatments in this experiment. The non-Bollgard II treatment may have had greater fruit loss earlier and hence the demands on the crop during the hot dry period experienced were less. When rainfall occurred later in the season if the Bollgard II crop had already cut-out the demand from the developing bolls may have prevented further vegetative and reproductive growth, however the conventional crop with lower demand from fruit may have been able to continue both vegetative and reproductive growth delaying cut-out. Some evidence of the better growing conditions later in the conventional crop is highlighted by the increased micronaire in Sicot 189RR. Higher micronaire in cotton crops can indicate improved growing conditions during boll development (Hearn 1985).

There was no evidence in these experiments that Bollgard II reacted any differently to conventional non-Bollgard II cotton across row configurations. If earlier and higher fruit loads in Bollgard II had significantly affected the resources of the plant so as to limit root exploration into the skip, as well as limiting the time to explore the skip, the analysis of results would have shown a significant interaction reflecting a lowered yield of the Bollgard II variety in skip row configurations. This was not the case: in neither experiment was an interaction found: Sicot 289BR followed the same trend in yield across the different configurations as Sicot 189RR.

The relative lint yields among row configurations varied between the experiments. In Exp. 1 the solid configuration out yielded skip row configurations by 18%. This is consistent with a difference of 16% presented in a summary of Australian cotton industry experiments (Bange et al. 2004). The lack of differences in lint yield among configurations in Exp. 2 is most likely due to the period of extremely dry and hot weather experienced 60 to 80 days after sowing (Figure 1). This major event would have caused significant fruit loss in all treatments as high temperatures and water stress combined causes major fruit shedding (Hearn 1979). The higher plant density in the solid planted treatment would have the potential to increase the fruit loss. That is, the solid configuration would have had the greatest fruit loss and double skip configuration the lowest. Consistent with this, an analysis of the yield components at the end of the season (data not shown) indicated that the solid configuration had more but smaller bolls and final fruit retention (final boll number/total fruiting sites produced) tended to be less.

Rain-fed cotton crops are susceptible to significant price discounts associated with reductions in fibre length (Bange et al. 2004). In these experiments the Bollgard II treatments did not cause any changes in fibre length. As expected, the skip row configurations provided some insurance against reductions in fibre length for both varieties. Across both experiments the double skip configuration had the longest fibre length. Based on 2006 price discounts there would have been some discount incurred by the double skip in Exp. 1, however, both single skip and the solid configuration would have been penalised more severely. In Exp. 2 single and double skip would not have incurred any discounts compared with solid which would have incurred a minor penalty. Superior gross margins from skip row cotton can be achieved due to savings in variable costs, and by maintaining fibre quality through the extra soil water available for developing bolls (Bange et al. 2004).

Conclusion

There were no indications that Bollgard II responded any differently to conventional cotton when grown in skip configurations. Skip row configurations may slightly reduce cotton lint yield potential, but can provide insurance against significant price discounts for poor fibre quality as well reducing variable costs. Overall the results suggest that cotton growers should consider skip row configurations with Bollgard II crops in the same manner as conventional cotton when considering potential yield and quality.

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