

Raingrown Bollgard II® Cotton – Performance Review

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Introduction

The Australian cotton industry has now had three seasons of commercial scale use of Bollgard II®, the two Bt gene product developed by Monsanto for insertion into cotton for control of Heliothis. This follows seven years of use of the single gene Ingard® product. A combination of factors including: excellent efficacy against the target pest, a rapidly expanding suite of varieties containing the product, a stepwise increase in the technology fee, no cap on the percentage of a farm that can be grown to Bollgard II® and management benefits associated with its use has seen a rapid increase in the acceptance of the technology across both the irrigated and dryland sectors of the industry (Table 1)

Table 1. Uptake of Bollgard II® technology across the sectors of the Australian cotton industry subsequent to its introduction for the 2003 plant (Data courtesy Monsanto Australia)

Season	% cotton area under Bollgard II® Roundup Ready®		% cotton area under Bollgard II®		% cotton area Non-Bollgard	
	Irrigated	Dryland	Irrigated	Dryland	Irrigated	Dryland
2003/04 *	17.1	12.3	45.5	26.1	65.8	54.4
2004/05	14.5	16.2	25.3	37.5	14.8	26.4
2005/06	68.4	71.5	29.2	36.4	19.4	19.2

* 2003/04 figures include Ingard® acreage

The three seasons have not been amongst the biggest plant dryland seasons, because of poor profile moisture and low prices at the commencement of the season. Working on a green hectare basis, the percentage of the total cotton area grown as dryland over the three seasons is 21%, 8% and 11% respectively. However, a large proportion of dryland cotton is grown using skip row configurations and as most other industry statistics are based on a ‘paddock’ area basis, the dryland percentage of the industry would be approximately half as big again each season.

Many of the dryland cotton growers are scattered amongst grain and livestock producers and the dramatic reduction in topical insecticide requirements for their crops has had an enormous positive impact on both their own time management and lifestyle as well as their relationship with non-cotton growing neighbours.

Economic Challenges for Dryland Bollgard II®

There are a number of issues which are of importance when discussing the economic challenges which are presented in production of dryland Bollgard II®. Australian dryland cotton production systems

have been in a constant state of change over the last twenty years, and are still evolving, as evidenced by the current level of interest in very wide row planting configurations. Many of the issues raised in this discussion are a consequence of practices adopted to manage previously encountered problems.

Technology fee

Traditionally, the greatest costs associated with dryland cotton production have been picking costs and Heliothis control. This latter cost, in conventional dryland production, has been characterized by enormous variability on a seasonal and regional basis. This has led to an inability to effectively budget for it each season. The payment of a technology fee removes the variability, allowing better budgeting. As well, there is room to negotiate in relation to the time of payment of the fee during a season. The concession in fees to cater for skip row plantings has been a substantial factor in making both Ingard® and Bollgard II® more attractive to dryland growers. Examples of configuration and percentage of full paddock fee paid include: single skip or 60in single row (66%); double skip or 80in single row (50%); super single (33%) and 2 out of 8 rows (25%). There has been some discussion on reducing the technology fee even further on a sliding scale in instances of low yielding crops eg < 2.0 b/ha - however nothing further has progressed on this proposal at this stage.

Fibre quality discounts

The recent move to set base staple length as a 36 (>1.10 or 35/32nd inch) has had a significant impact on the ability of dryland Bollgard II® growers to avoid discounts. Table 9 illustrates the variability that occurs in both yield and fibre quality in dryland production systems over a period of time, under the same crop management system. Dryland produced cotton is characterized by an overall lower average staple length because of periods of soil water shortage during boll development. Level of starting soil moisture, varietal selection and row configuration choices are the major way to manage for this limitation.

Pupae busting requirements

The need to conduct pupae busting is a requirement of the Bollgard II® licence. Not only is it a costly operation, but also it often has to be carried out under unfavourable soil conditions (too wet or too dry!). This can contribute to an inability to successfully establish a winter cereal double crop for provision of ground cover for the following summer. While obviously a critical component of the technology resistance management strategy, it is hoped that other developments will occur to reduce the need for this aggressive tillage operation.

Refuge requirements

Because of the difficulty in maintaining Heliothis attractiveness in other dryland crops, most dryland Bollgard II® growers have to resort to a 10% unsprayed cotton option as their refuge. This represents a significant added cost to production, which unlike the technology fee, cannot be reduced on a green acre basis. Depending on Heliothis pressure and seasonal conditions, unsprayed refuges can often produce enough yield to warrant harvesting; however this is not always a certainty.

Control of Roundup Ready® volunteers and regrowth

All dryland cotton is produced subsequent to a fallow of 12-18 months to accumulate soil moisture to depth. Weed control with glyphosate during that fallow has been a relatively inexpensive component of dryland cotton systems. The increased use of Bollgard II® stacks in dryland systems means that a more sophisticated and expensive control strategy is necessary in fallows following the prior use of this technology.

Planting within a six week window

In a dryland situation where 90% of time, planting is dependent on timely adequate rainfall during spring, the restriction of planting within a predetermined six week planting window can create a number of problems. Often, it is unwise to order seed until the rainfall event, in which case, both varietal choice and seed treatment choice can be limited and seed availability can be delayed. Planting either before or after the window restricts growers to non-Bollgard II® varieties, with all the associated management problems. In years when price is low, another commodity is likely to be sown, but in years with more attractive prices, the latter option is more likely. Failure of winter crop, with resultant bare fallows increases this uncertainty of timely planting.

Weed control in wider rows

A considerable body of information now exists to make skip row and wider row configurations attractive from a gross margin aspect, when penalties for below base grade quality are factored in. However, the wider row spacing with no crop cover encourages weed problems especially the likes of fleabane. Crop competition for light has always been seen as a core component of integrated weed control and this is removed with ever wider row spacings. With it comes a greater threat of herbicide resistance to glyphosate, and a need for additional cultivation operations which can result in reduced in-crop rainfall capture. With these wider row configurations comes the need for better guidance systems for accuracy in cultivation and shielded spraying operations.

Ground rig applications

Maintaining tight control on costs is paramount in dryland cotton growing because of the greater uncertainty associated with the production system. The necessity of having to apply insecticides broadcast aerially because conditions are unsuitable for banded applications by groundrig can wreck havoc on a budget. As well, the availability of both suitable product and an aerial applicator can be difficult. The use of good monitoring and plant mapping techniques for sucking pests continues to be important especially to assist with application decisions during prolonged wet periods.

Integrated Pest Management (IPM) in Bollgard II®

The reduction in topical insecticide applications in Bollgard II® provides a great stepping board for IPM due to increased survival of beneficial insects. With this however, comes a risk of increased survival of 'secondary' pests such as mirids, aphids, stink bugs, mites and silverleaf whitefly. If left

unattended, the costs of a ‘salvage operation’ trying to control these can be extreme and damage to yield and fibre quality from these pests can be devastating.

To best manage both of these situations, it is important that Bollgard II® crops are monitored regularly by an experienced agronomist or crop consultant. Their importance in this situation is equally as important as in conventional cotton.

Bollgard II® Agronomic Research – Dryland

Row configuration options

This topic will be covered by Bange (refer this proceedings). The adoption of skip row configurations has accelerated in dryland cotton with the uptake of Bollgard II®. Reasons include:

- Technology fee concessions.
- Tightening of fibre length requirements on Premium and Discount sheets.
- Less concerns about large crops creating late season insecticide application problems
- Ability to reduce costs of defoliation and picking
- Able to do most passes via groundrig due to a reduction in urgency of pest treatment
- Perception that Bollgard II® crops could be at greater threat of shorter staple length

Plant population studies in dryland Bollgard II®

Plant population trials in dryland Bollgard II® have been conducted by CSD over the last three seasons. At Dalby and Kupunn, the trials have been small plot replicated studies, picked with a plot picker, with treatment samples handled in the same fashion as samples from all CSD dryland variety trials.

Table 2. Plant population trials in 2005/06 at two dryland sites near Dalby; Sicala 350B

		3/m	5/m	7/m	9/m	11/m	13/m
Site 1 (single skip)	Yield (b/ha)	-	1.85	1.95	1.95	2.03	2.12
	Staple (ins.)	-	1.19	1.24	1.18	1.23	1.22
	Mic	-	4.7	4.4	4.5	4.4	4.8
Site 2 (double skip)	Yield (b/ha)	2.28	2.30	2.62	2.57	2.77	2.64
	Staple (ins.)	1.14	1.16	1.15	1.16	1.17	1.17
	Mic	4.2	4.3	4.3	4.3	4.4	4.2

Table 3. Plant population trial results averaged over two seasons (03/04, 04/05) at Kupunn; Sicot 289B, double skip planting

	3/m	5/m	7/m	9/m
Yield (b/ha)	3.72	3.89	3.94	4.04
Staple (ins.)	1.10	1.12	1.12	1.12
Mic	4.5	4.5	4.5	4.5

These four trials, spread over three seasons give a reasonably consistent story. The lighter populations (3/m, 5/m) are lower yielding (significantly in two of the trials) than the higher plant populations. There appears to be a slight upward trend in yield with plant populations to about 10-11/m and then it drops away. However, there is no significant difference in yield in the range from 7/m to 13/m in any of the trials. The 2003 trial also provided data for 11/m and 13/m treatments, which followed a trend similar to Dalby Site 2 above (Table 2). There has been no significant difference in staple or micronaire between treatments in any of the four trials. The only slight trend is to shorter staple length at the lowest (3/m) population, a reflection perhaps of a much higher proportion of the crop being set on vegetative branches.

A trial using commercial size plots at ‘Glencairn’, Narrabri this last season gave a contrary result however. In this instance, a population of 5 plants/m out yielded treatments of 8/m and 16/m. There was no significant difference in fibre quality (Table 4). A similar trial at Bellata last season with Sicot 289BR resulted in the same yield of 3.6 bales/ha for populations of 4 plants/m and 8/m , with a slight yield drop to 3.5 bales/ha for 15/m. Staple length was 1.12 ins, micronaire 4.8 for all three treatments.

Table 4. Commercial size plant population trial (05/06) at ‘Glencairn’, Narrabri; Sicot 289BR

	5/m	8/m	16/m
Yield (b/ha)	2.30	1.92	1.90
Staple (ins.)	1.11	1.09	1.11
Mic	4.4	4.5	4.2

Based on the results from the three years of trials, it would seem that dryland Bollgard II® producers growing cotton in skip row and wide row configurations should aim to establish a population in the 8-10 plants/m range. There is no evidence of yield or quality decline from stands of up to 11 plants/m in any of these trials, whereas some trials have shown a yield decline with stands of 5 plants/m and less. Populations in the recommended range produce the majority of the crop on mainstem nodes, and less on vegetative branches, which can reduce boll damage from passage of ground rigs in big crops, and appears to result in slightly better fibre quality.

Delaying fruiting by topping/slashing

A significant change in crop fruiting dynamics with the adoption of Bollgard II® cotton is the greater retention of early fruit. In dryland production systems this has sometimes been associated with premature cut-out, particularly in earlier planted situations. In these cases, where soil water may become limiting in early boll fill, competition for resources favours bolls, at the expense of vegetative growth.

One technique suggested as a means of trying to improve fibre quality in early planted Bollgard II® crops on less than favourable soil moisture profiles is to top the plants by slashing at first square,

thereby delaying the time of peak flowering. A small plot trial was conducted in the 2004/05 season near Dalby to evaluate the effect of topping on yield and fibre quality of Bollgard II® cotton

Planted on a full profile in early November, the crop received good rainfall up until the start of January. During the next three months, no effective rainfall was received (40mm spread across eight falls) The topped treatment was at peak flower in early February, about two weeks behind the untreated, which had flowered with 75% first position retention. Lack of soil moisture meant the slashed treatment never held the same fruit load as the untreated, which affected final yield. However, staple length was marginally better in the slashed treatment (Table 5)

Table 5. Yield and fibre quality from topping trial (04/05) at Kupunn; Sicot 289B

	5 plants/m untreated	5 plants/m topped
Yield (b/ha) *	2.87	2.50
Staple (ins.)	1.09	1.10
Mic	4.8	4.8

* significant difference

When this trial is repeated, an earlier planting date and lower profile moisture site will be used.

Segmented picking – dryland crops

Over the last two seasons, the CSD E&D team have been carrying out segmented picking on a number of crops across the different growing regions to better assess the influence of climatic and management criteria on final yield and fibre quality. A number of dryland crops were assessed this season.

One was a crop of Sicot 289BR, grown in the Brookstead area on fallow from wheat and planted in a ‘two out of eight’ row configuration (25% green acre). The crop performed extremely well, due to well spaced rainfall events right through into February, yielding 4.1 bales/ha, or 16 bales/ha in the row, from a stand of 12 plants/m and a final plant height of 1.25m (Table 6).

Some noticeable features on yield are the low retention (11%) of the fruiting branches 1-4 (FB 1-4), first position segment and the relatively low yield contribution from this segment (2.75%), contrasted with the high retention (60%), biggest boll size and major yield contribution coming from segment (3), which represents first position bolls on FB 9-12. Being dryland, soil moisture levels obviously varied enormously, which is illustrated by the spread in staple length across the crop. The crop was grown right out, and defoliated in mid April, with lower micronaire showing up in the latest maturing crop segments (4) and (7).

Table 6. Segmented pick data from dryland Sicot 289BR crop, Brookstead, 2005/06, ‘two out of eight’ row configuration

Segment No.	Segment	Bolls/m	Yield (b/ha)	Boll size(g/boll)	Staple (ins)	Mic
(1)	FB 1-4, 1 st posn	5.5	0.42	1.74	1.19	4.8
(2)	FB 5-8, 1 st posn	23	1.96	1.93	1.18	4.6
(3)	FB 9-12, 1 st posn	29	2.79	2.19	1.16	4.9
(4)	FB >12	25	2.31	2.09	1.15	4.1
(5)	FB 1-4, 2 nd + posn	21	1.72	1.85	1.18	4.7
(6)	FB 5-8, 2 nd + posn	33.5	2.74	1.85	1.13	4.5
(7)	FB 9-12, 2 nd + posn	21.5	1.54	1.63	1.20	4.3
(8)	Veg. branches	42.5	1.46	1.88	1.18	4.6
(9)	Tipped plants	9	0.32	1.92	1.16	4.9
		208	15.26		(1.17)	(4.5)

The data from this trial dispels a lot of myths about dryland crop performance. It is not necessary to have high first position retention levels in the lower crop to achieve big yields. The combination of good soil nitrogen levels, excellent soil moisture at depth, well spaced incrop rainfall, good drainage to minimise early waterlogging and careful spacing of wheeltracks to minimise compaction adjacent to the row have all combined in this situation to produce an outstanding result, from both a yield and fibre quality consideration.

Bollgard II® Agronomic Performance – Yield and Quality

Obviously, long term performance data for Bollgard II® in dryland is very limited. However, a few comparisons between Bollgard II® varieties and parent conventional lines for the last two seasons do exist. Table 7 shows data from CSIRO small plot evaluation trials conducted at five sites over two years.

Table 7. Comparative performance of Bollgard II® varieties and parent variety – CSIRO fully sprayed small plot trials (2003, 2004 plant years x 5 site average)

Variety	Rel. yield (%)	Staple (ins.)	Mic
Siokra V-16	100	1.10	4.3
Siokra V-16B	98	1.12	4.0
Siokra V-16BR	91	1.15	3.6

Very few formalized commercial scale side by side comparisons of a Bollgard II® variety and its parent exist. However, Siokra V-16BR has been included in the CSD conventional variety trial at Bellata over three seasons, and can be compared with Siokra V-16 in this situation. (Table 8)

Table 8. Comparative performance of Siokra V-16 and Siokra V-16BR in CSD Bellata conventional (fully sprayed) variety trial over three seasons (2003/04 – 2005/06)

Plant Year	Variety	Yield (b/ha)	Staple (ins.)	Mic
2003	Siokra V-16	2.3	1.15	4.5
	Siokra V-16BR	3.0	1.17	4.0
2004	Siokra V-16	2.3	1.06	4.4
	Siokra V-16BR	2.9	1.09	4.0
2005	Siokra V-16	2.5	1.14	4.5
	Siokra V-16BR	2.5	1.15	4.2
Average	Siokra V-16	2.4	1.12 (36)	4.5
	Siokra V-16BR	2.7	1.14 (36)	4.1

Both sets of data illustrate that while growth habit, appearance and performance of a conventional variety and its Bollgard II® derivatives are generally similar, they can vary somewhat in key characteristics, especially fibre quality, and they need to be carefully assessed as individual varieties.

Table 9 shows the performance of the conventional variety Siokra V-16 at the same CSD variety trial location over a ten year period. Management has been basically the same each season, with the trial planted into a no-till seedbed with cereal cover, using a double skip planting configuration. The variability in yield and fibre quality and *Heliothis* pressure which characterizes dryland cotton production is clearly illustrated in this data.

It is our belief that varieties with Bollgard II® have the potential to improve yield and/or fibre quality compared with similar conventional varieties in a couple of different situations, which will be outlined using this data set. 1996, 2004 and 2005 were near identical seasons at this location with good early rain but basically nothing after Christmas. *Heliothis* pressure was high early, with retention down to about 20% at first flower. The crop put more fruit on during January, but moisture stress impacted on fibre length in these later bolls. Under a similar scenario, a Bollgard II® variety is likely to retain a higher proportion of those early fruit, where fibre elongation is occurring under better moisture conditions. The dry conditions will impact similarly on the crop, so yield is not likely to differ markedly – however fibre length should be better.

In those seasons where good rain doesn't arrive until late eg early February, Bollgard II® crops in dryland have the potential to resume vegetative growth and produce a 'second' crop, without the need for a heavy insecticide program, which was the situation at this Chinchilla site in 1997. This 'second' crop scenario was seen in some Bollgard II® crops in the Moree area this season, where basically 1.5 b/ha was produced from early season rainfall and stored moisture, and an additional 3.75 b/ha late crop was produced from the rains which started in February.

Table 9. Ten year yield and fibre quality summary for Siokra V-16 in CSD Chinchilla conventional variety trial

Plant Year	Yield (b/ha)	Staple (ins.)	Mic	No. Hel. Sprays
1996 *	3.9	1.10 (35)	4.5	8
1997	4.0	1.17 (37)	4.9	12
1998	2.8	1.19 (38)	3.9	14
1999	5.0	1.19 (38)	4.3	3
2000	2.8	1.16 (37)	4.9	5
2001	2.9	1.16 (37)	5.0	8
2002	No planting			
2003	4.6	1.14 (36)	4.6	7
2004	1.9	1.09 (35)	4.7	5
2005	2.4	1.09 (35)	4.7	8

* Siokra V-15

Recommendations for Management of Dryland Bollgard II®

The management considerations for Bollgard II® in dryland production systems are not dissimilar to those of conventional cotton.

- Avoid early planting when profile moisture is marginal; alternatively, plant a proportion only, with specialist long staple varieties
- Double skip row configuration provides a good compromise between yield and maintenance of above base fibre quality on the majority of dryland cropping soils
- In all skip row configurations, aim to establish 8-10 plants/m, thereby minimizing gaps and reducing the amount of vegetative branching, the latter contributing to problems with ground rig operations and picking efficiency
- If rain comes late in the season, Bollgard II® presence provides the potential to set a good crop; however, it is important to preserve predators to ensure sprays for secondary pests don't blow out
- Remember that sucking pest control practice options must now be made with the spectre of silver leaf whitefly (SLW) in the background
- High first position retention on the first 4-5 fruiting branches is not a necessity for achieving good yields in dryland Bollgard II® (see Table 6).
- Secure the services of a experienced agronomist or consultant. While Heliothis management is much less crucial in Bollgard II® crops, it is still important to monitor and manage other potentially damaging pests including mirids, aphids, stink bugs, mites and SLW.