Cotton
Update 2006

Department of Agriculture & Food

GM cotton research in the Ord River Irrigation Area

Inside this brochure:

GM cotton trials impressive!

Picking the 2005 cotton trials at Kununurra was completed in September and the results were very impressive. The yield from the large 25 hectare Bollgard II® demonstration paddock was a local record of 9.4 bales/ hectare. This compares favourably with the Australian industry average of 9.2 bales/hectare and improved on the previous two years which yielded about 8.5 bales/hectare.

Perhaps even better news is that the excellent yields were achieved with few insecticide applications and low water use relative to other crops in the area.

The focus of cotton research has always been on sustainability as well as high yield. For this reason it is especially pleasing to achieve high yields without compromising the important principles of sustainable pest and soil management.

The Department and its research partners have conducted cotton trials at Kununurra for 10 years. During that time, and with the enormous support of local farmers, more than 3,000 hectares of GM cotton have been evaluated. Despite some difficult years, there is now great confidence in the draft production package produced through this collaboration.

The guidelines for sustainable cotton production in the east Kimberley will be published in mid-2006 by the Cotton Catchment Communities CRC.

A mature cotton boll opening

This update gives a summary of research results obtained at Kununurra.

The first GM cotton harvest at Kununurra, 1997.

How is GM cotton regulated?

All dealings with GM material in Australia are controlled by the Gene Technology Regulator under the powers of the *Gene Technology Act 2000*. The Regulator undertakes a thorough evaluation of the **health** and **environmental impacts** of all GM releases into the environment, including research trials. In September 2002, the Regulator approved the commercial release of Bollgard II® and Bollgard II®/Roundup Ready® cotton in Australia below latitude 22°S. However, commercial release approval was refused in northern Australia due to the Regulator's concerns that the crop may become a weed in the tropical environment (update page 5).

Most States also have legislation restricting the growing of GM crops. In Western Australia, the *GM Crop Free Areas Act 2003* prohibits the growing of all GM crops unless the Minister for Agriculture provides an exemption for a particular GM crop and/or area. GM cotton is grown in Queensland because the State does not have a moratorium and in NSW because the State considers that cotton is not a food crop and therefore falls outside the scope of its GM food crop moratorium.

A novel production system

The famously unsuccessful attempt at cotton growing at Kununurra in the 1960/70s dramatically illustrated the importance of sustainable production systems. The almost total reliance on insecticides to control insect pests led to pests developing resistance to the chemicals and eventually the industry collapsed.

The development of GM cotton varieties, containing genes that give plants resistance to caterpillar attack, has opened the door to the prospect of redesigning sustainable cotton production systems for the Kimberley. Differences between the unsuccessful "old industry" and the new model for sustainable production are summarised in the table below.

1970s INDUSTRY	NEW INDUSTRY	BENEFITS
Summer cropping (wet season)	Winter cropping (dry season)	Avoids major pests – pink bollworm, *Spodoptera*
Conventional varieties	Transgenic varieties	Controls caterpillar pests
Broad spectrum insecticides (>20 sprays per season)	IPM systems (<5 sprays per season)	Environmentally friendly - few insecticide sprays
No pesticide resistance management	Pre-emptive Bt resistance management	Long-term sustainability

What research has been done?

A comprehensive range of studies has been undertaken, as summarised in the following table.

The research between disciplines has been well integrated with the result that a cohesive package for sustainable production has been drafted. The final package will be released as "NORpak" in mid-2006. A series of Factsheets highlighting research achievements will also be published in 2006.

Pest management	Crop husbandry	Environmental issues
large-scale IPM	nutrition	GM cotton weediness
GM cotton efficacy	varieties	water runoff quality
trap crops	crop growth	water use efficiency
resistance management	irrigation	Integrated weed management
beneficial insects	minimum tillage	"soft" insecticides

Who's been involved with cotton research?

Cotton research at Kununurra has been a large collaborative effort between research organisations, local farmers, businesses and industry funding organisations. Key amongst these are the Department of Agriculture & Food, CSIRO, the Australian Cotton CRC, Cotton Research & Development Corporation, Colly Cotton, Ord River District Cooperative, Cotton Seed Distributors and Monsanto Australia. Most importantly, local farmers have invested in cotton growing and produced more than 3,000 hectares of GM cotton on a high risk research basis. Torben Sass Nielsen invested in cotton picking and module building equipment, without which the trials could not have been possible.

Yields at Kununurra

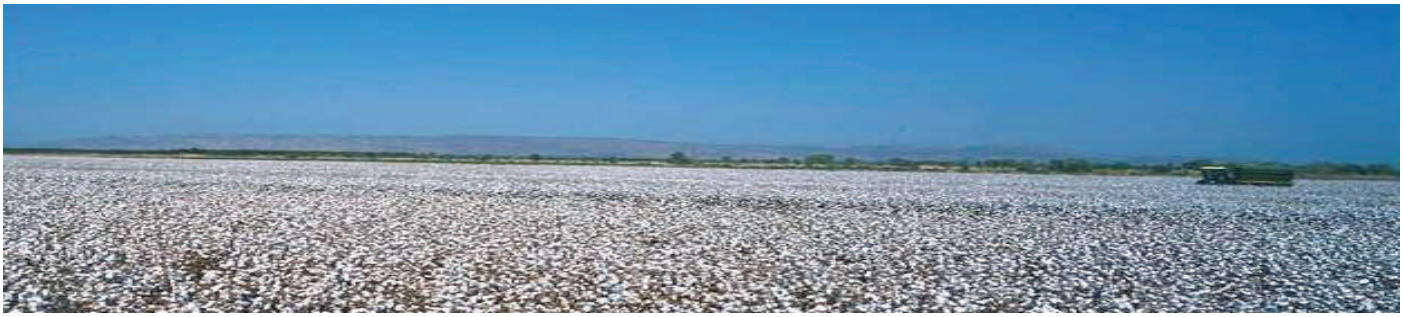
Bollgard II® demonstration paddocks have been grown at Kununurra according to best management systems (NORpak) for the past three seasons.

Yields are clearly commercially acceptable. Although Kununurra is not an inherently high yielding area, it produces reliably without the risks of drought, floods and summer storms.

Year	Kununurra (Bollgard II®)	Australian industry average	World average
2003	8.4 bales/hectare	7.4 bales/hectare	2.8 bales/hectare
2004	8.5 bales/hectare	7.8 bales/hectare	3.1 bales/hectare
2005	9.4 bales/hectare	9.2 bales/hectare	3.2 bales/hectare

Source: Cotton Yearbook 2005 & local data.

Steve Yeates (CSIRO) admiring Ord cotton.



Irrigation application and efficiency

Cotton can be irrigated with any of the standard techniques including drip, lateral move, centre pivot or furrow. Almost all cotton research at Kununurra has utilised furrow irrigation because it is the standard for the region and enables direct comparisons with other crops.

Considerable research effort has been devoted to developing efficient irrigation strategies for cotton. In essence, the preferred method involves scheduling irrigation events according to how much soil water the crop has used. This can be measured directly by soil moisture probes or by calculating water loss using a formula based on plant size and daily evaporation data from the local weather station. Cotton crops at Kununurra typically require eight irrigations during the 6 month life of the crop, including initial crop establishment.

The following table summarises the irrigation data from Bollgard II® demonstration crops grown at the Frank Wise Institute.

Irrigation events were meticulously monitored with all water on and off the paddock measured.

Year	Total water applied/ha	Water application efficiency
2003	7.5 Megalitres	83%
2004	7.0 Megalitres	73%

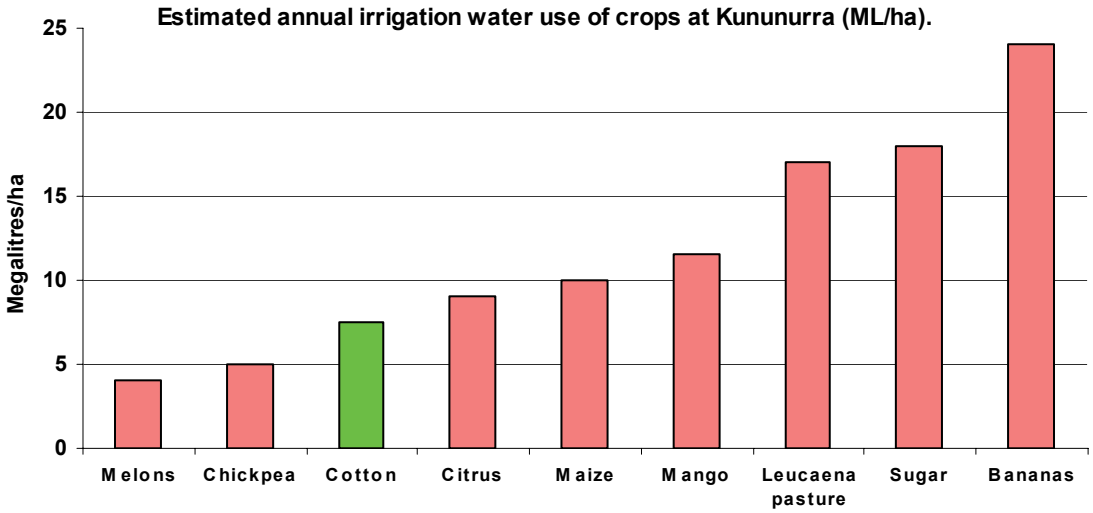
John Moulden (DAFWA) measuring water runoff from an irrigation experiment.

Research data shows that Bollgard II® has a moderate irrigation requirement (~7.5 Megalitres/hectare) and that high water application efficiencies (~80%) can be achieved in the traditional furrow irrigation system.

Measuring irrigation efficiency is an important research activity.

How much water does cotton use?

Urban mythology suggests that cotton is a "thirsty" crop, but trial data shows that cotton has a modest irrigation water requirement at Kununurra of about 7.5 Megalitres /hectare. This compares favourably with other crops commonly grown in the region, as shown in the chart below.



Source: Dr J Sherrard, Department of Agriculture & Food, unpublished data.

Is GM cotton economic to grow?

Picking cotton at Kununurra.

State and Federal legislation currently precludes the commercial growing of GM cotton at Kununurra and therefore there is no opportunity for an industry to develop at this time. However hypothetical gross margin budgets for cotton growing at Kununurra have been developed and published. The budget assumes the availability of picking and ginning equipment and these costs are included in the budget. Gross margins for all crops fluctuate according to changes in exchange rates, input costs and world prices. However, an average gross margin for GM cotton production at Kununurra is typically about $1,200 per hectare. This compares favourably with other crops in the ORIA.

The region's guaranteed water supply and consistent yields mean that farmers would have the advantage of accessing forward selling strategies to capture high prices. This is an important distinction between Kununurra and most other production areas in Australia that suffer from water uncertainties and reduced marketing opportunities.

Relative gross margins for selected crops at Kununurra.

Cotton	Sugar	Chickpea	Pumpkin	Sorghum (Grain)	Sorghum (hay)	Maize
$1,200	$270	$160	$800	-$140	$270	-$210

Source: Department of Agriculture & Food, field crop budgets 2004.

Pest management

IPM (integrated pest management) principles have been rigorously evaluated at Kununurra in large-scale trials over a 10 year period. Local farmers have test-farmed novel IPM systems on more than 3,000 hectares cumulatively during the research phase. Key results from this research are summarised as:

- winter cropping (rather than summer) avoids peaks in abundance of some major pests, especially the pink bollworm and cluster caterpillar
- using a combination of trap crops and IPM compatible insecticides to control minor pests maximises the effectiveness of naturally occurring beneficial insects
- Bollgard II® effectively controls caterpillar pests throughout the season and is the cornerstone of successful IPM. The only exception is cluster caterpillar, which can occur as a minor pest in some seasons
- few sprays (<5) are required to manage insect pests on Bollgard II® cotton, compared to the 20-40 sprays that were required for summer grown conventional cotton in the 1970s

Bollgard II® cotton requires a moderate level of spraying for insect pest control compared to other crops in the region.

Inspecting an IPM cotton crop at Kununurra.

Will GM cotton become a super weed?

When Bollgard II® and Bollgard II®/Roundup Ready® cotton was approved for commercial release in 2002, the Gene Technology Regulator refused approval for northern Australia citing concerns about potential environmental weediness. At the time of the Regulator's decision, detailed multi-site weediness research conducted by CSIRO had not been completed.

However, the research is now completed and published by the NT Government. Key results are expected to be published in the scientific literature in the near future and forms the basis of a new application to the Regulator for a commercial licence in northern Australia.

The CSIRO research was conducted in three regions; south of Broome, around Kununurra, and in the vicinity of Katherine. Detailed studies involving conventional cotton and two types of GM cotton occurred at each of several sites in all of the three regions. The trials were monitored for five years or until all plants had died.

At no site did a viable self-sustaining population of cotton establish.

The major conclusion from the research was that cotton is not an environmental weed and GM cotton does not have a higher weediness risk than conventional cotton.

(Full report at: http://www.cotton.crc.org.au/Assets/PDFFiles/TB3051.pdf)

Will insects become resistant to GM cotton?

Bollgard II® cotton contains two genes, which produce two different proteins that control the caterpillar pests that ingest them. The genes originated from a soil bacterium called *Bacillus thuringiensis*, commonly known as "Bt". Bt sprays have been used in agriculture for over 50 years and are favoured by organic farmers that use it as a natural control. Bt products are considered very safe to the consumer and are readily available in garden shops and supermarkets.

Insects can develop resistance to insecticides in a similar way to human diseases developing resistance to antibiotics. In the case of the Bollgard II® genes, it is known that resistance genes exist naturally in pest populations, but at very low levels. The key to successfully managing resistance is maintaining the frequency of resistance genes at low levels.

Considerable research effort is devoted to Bt resistance management. In fact, the area of INGARD® cotton in Australia was capped at 30% until the less resistance-prone Bollgard II® varieties were developed. It is a legal requirement for every region growing Bollgard II® cotton to have an approved and audited Resistance Management Strategy in place. A key to all strategies is the provision of a "refuge crop" with all Bollgard II® plantings. The refuge crop is unsprayed and provides a large source of moths that have not been exposed to Bt. These moths are then available to mate with any Bt resistant individuals, therefore "diluting" the resistance level in the pest population. A draft Resistance Management Strategy has been prepared for Kununurra.

Department of Agriculture & Food

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Visit the Cotton Catchment Communities Cooperative Research Centre at: http://www.cotton.crc.org.au/

Cotton Catchment Communities CRC

What is GM cotton?

There are two types of GM grown commercially in Australia:

- Bollgard II® - cotton varieties containing two bacterial genes that provide protection against common caterpillar pests. (In 2003, Bollgard II® replaced INGARD® , which contained a single Bt gene and had been grown since 1996)
- Roundup Ready® - cotton varieties that are tolerant to the common herbicide glyphosate during the early growth stage

Both these genetic traits were developed by Monsanto and, in Australia, have been incorporated into Australian bred varieties by CSIRO and Deltapine Australia. CSIRO varieties are marketed by Cotton Seed Distributors and have more than 80% of the market share.

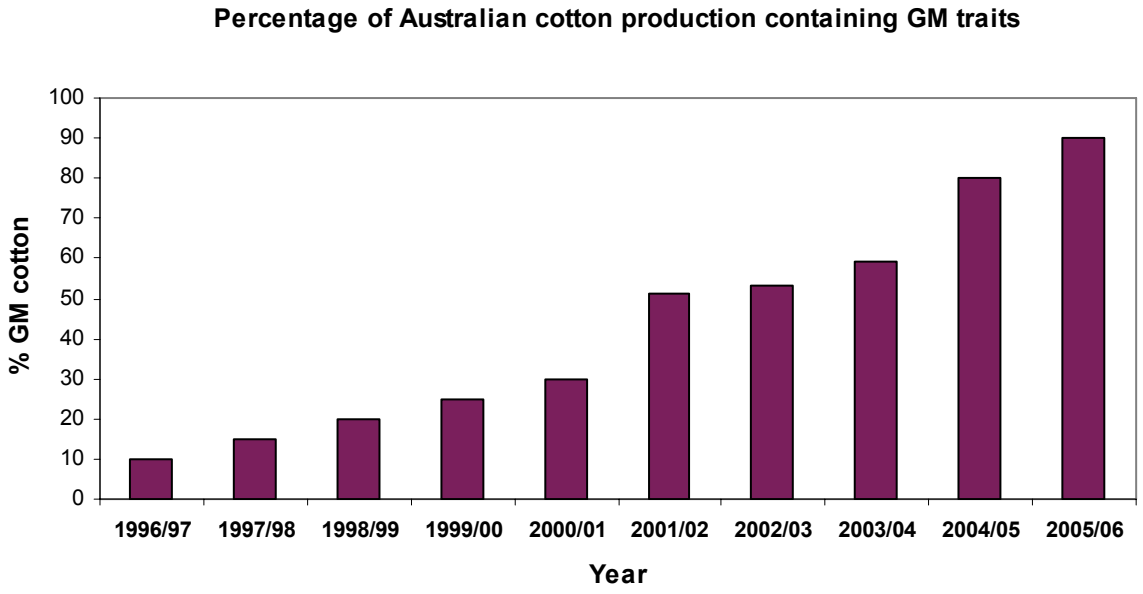
Cotton growers in eastern Australia have the choice of growing conventional cotton or GM cotton that contains either or both of the insect and herbicide tolerance traits. Farmers have adopted GM technology readily and 90% of the 2005/06 crop contained GM traits.

The major impact of GM cotton in eastern Australia is an 85% reduction in insecticide applications since 1998. Future cotton production in the Kimberley would also need to be GM based to capture these environmental benefits.

Note: ® Bollgard II, Roundup Ready and INGARD are registered trademarks of Monsanto Technologies LLC used under licence by Monsanto Australia Limited.

History of commercial GM cotton production in Australia

Australian cotton farmers have adopted GM technology readily and 90% of the 2005/06 crop contained one or more GM traits.



Source: Annual audit figures from Monsanto Australia.

Australian Government
Cotton Research and Development Corporation

Department of Agriculture and Food
Government of Western Australia

CSIRO