Agricultural Biotechnology Council of Australia

GM Cotton in Australia: a resource guide

RESOURCE GUIDE 3

The following is a reference guide providing information about genetically modified (GM) cotton in Australia, and some of the research in the pipeline. The guide provides information on the cotton industry, an overview of GM cotton varieties and the regulation surrounding them, the science behind the crops, how they perform, the use of cotton in human and animal foodstuffs, and further information resources.

1 Industry background

In an average production year, Australia's cotton industry is worth more than $1 billion annually, and there are around 1500 cotton-growing families across NSW and Queensland. A small area of cotton was also trialled as part of Western Australia's Ord River Scheme in 2011.

Cotton has many uses, the most common being the production of clothing. It is also used for familiar products such as cotton buds, and less known products like bank notes, x-rays and upholstery. Cotton seed is pressed to extract the oil from it, and this oil is used in the food industry, particularly by fast food and take-away outlets. The hull of the seed is also used as stock feed.

Genetically modified insect resistant cotton varieties were introduced to the Australian cotton industry in 1996. After 16 years of use, GM varieties now represent almost 100 per cent of cotton grown across the country.

2 Insect resistant cottons

Bt or Ingard®

In 1996, insect resistant GM cotton was grown commercially for the first time after six years of field trials. Known as Bt or Ingard® cotton, the cotton was developed by CSIRO, using a gene owned by Monsanto. This gene was sourced from the soil bacteria Bacillus thuringiensis (Bt), and it enabled the plant to produce the Bt protein which killed cotton's major pest, heliothis or the cotton bollworm, when it ate the leaves.

Prior to the introduction of GM cotton, growers spent approximately $50 million annually on insecticides to control cotton pests. Insect resistant GM cotton provided growers with an opportunity to implement more effective integrated pest management strategies into their farming systems, and reduce chemical use.

According to CSIRO, the use of Bt cotton allowed the industry to reduce pesticide applications by 56 per cent each season, with reductions of up to 80 per cent in some years. The use of Bt cotton was capped at 30 per cent by the cotton industry to minimise the chances of the heliothis pest developing resistance to the protein.

The regulatory details, including licence application information for Bt cotton can be found at: www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/DIR022-2002. Bt cotton has now been superceded by Bollgard II®, a new generation insect-resistant cotton.

Bollgard II®

Bollgard II® is the second insect resistant GM cotton to be approved for commercial release in Australia. Approved in 2003, it differs from Bt cotton in that it contains two genes from the soil bacteria Bacillus thuringiensis (Bt), rather than one. The genes produce proteins in the leaves of the cotton plant and when cotton's major caterpillar pest eats the plant, it dies.

Bollgard II was phased in and completely replaced Bt cotton in 2004. As mentioned above, while Bt cotton was capped at 30 per cent of the cotton crop for resistance management purposes, this cap does not apply to Bollgard II.

The licence application details regarding Bollgard II are available from: www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/dir012-3/$FILE/dir012lic21.pdf.

Bollgard II — the latest GM cotton was compiled by CSIRO in 2007, and is available from: www.csiro.au/~/media/.../Bollgard_CPI_pdf%20Standard.pdf. It outlines the history, regulatory considerations and management practices in place to manage the technology.

According to the Cotton Research and Development Corporation (CRDC), over the first three seasons of its use, Bollgard II varieties, on average, required only 18 per cent of the insecticide required for conventional cotton to manage pests. See: www.crdc.com.au/uploaded/File/Annual%20Reports/AnnualReport_06-07.pdf.

The CRDC *Annual Report 2010–11*, reports that the Bollgard II technology has made an enormous contribution to the viability of the Australian cotton industry over the past decade, and that due to a major resistance management effort since its introduction, the field efficacy of the technology remains unaffected. See: www.crdc.com.au/uploaded/file/Annual%20Reports/CRDC%20Ann%20Rpt%20 2010-11%20(FINAL%204%20OCT)_pdf.pdf.

WIDE STRIKE™

Dow AgroSciences entered the GM cotton market in 2009, when the OGTR approved its insect resistant variety marketed as WIDE STRIKE™. The GM cotton contains two genes, derived from a soil bacterium, that have been shown to increase resistance to insect pests. For licence application information, see: www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/DIR091.

3 Herbicide tolerant cottons — Roundup Ready®

Roundup Ready® cotton and Roundup Ready/Bt cotton, were commercially available for the first time in Australia in 2001. The Roundup Ready characteristic makes the cotton plant resistant to the herbicide glyphosate. Herbicide tolerant crops are not harmed by the herbicides applied to the weeds around them, providing growers with greater flexibility in weed control options.

Roundup Ready/Bt cotton was achieved through conventional breeding of the two GM varieties. Regulatory details and licence application information for Roundup Ready cotton can be found at: www.ogtr.gov.au/internet/ogtr/publishing.nsf/content/dir023-2002.

According to the CRDC, Roundup Ready® cottons have allowed growers to reduce their use of residual herbicides, which pose risks to land, water and biodiversity. For example, in the CRDC *2006–07 Annual Report*, www.crdc.com.au/uploaded/File/Annual%20Reports/ AnnualReport_06-07.pdf, a 32.4 per cent reduction in residual herbicide use was reported since the introduction of Roundup Ready technology.

For background information relating to herbicide tolerant crops, see *Agricultural Biotechnology: Herbicide Tolerant Crops in Australia* released in 2003 by the Commonwealth Department of Agriculture, Fisheries and Forestry (DAFF). The report examines herbicide tolerant crops, particularly GM herbicide tolerant crops, the reasons they are being developed and the rationale behind their use by farmers. The benefits and risks from growing these crops are examined, along with the strategies used to manage the risks. The aim is to inform the public debate about the technology and its potential in Australian agriculture. Copies of the report are available from: http://adl.brs.gov.au/brsShop/data/13235_htcrop.pdf.

Roundup Ready FLEX®

In February 2006, the Office of the Gene Technology Regulator (OGTR) approved the commercial release of Roundup Ready FLEX® cotton varieties. These varieties give growers greater flexibility in weed control by extending the period during which glyphosate can be applied to control weeds. Further regulatory information is available from: www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/dir059-2005.

Roundup Ready FLEX varieties are intended to replace the Roundup Ready varieties. They differ from Roundup Ready cotton in that they contain two copies of a glyphosate tolerance gene derived from a soil bacterium rather than just one.

Liberty Link®

In 2006, another company entered the GM cotton market in Australia, when the OGTR approved Bayer CropScience's Liberty Link® cotton. All the varieties mentioned previously have been developed by Monsanto, or by CSIRO using Monsanto technology. Liberty Link® cotton has been genetically modified to tolerate applications of the broad-spectrum herbicide, glufosinate ammonium, marketed as Liberty®. Glufosinate ammonium allows growers to control a different range of broad leaf weed species, as well as minimising the risks of herbicide resistance.

While the Roundup herbicide is a Group M herbicide, the Liberty herbicide is a Group N herbicide, therefore it has a different mode of action for killing weeds. It is useful for hard to kill weeds in cotton such as volunteer (self-sown) cotton, peach vine, sesbania pea and bladder ketmia. For licence application information, see: www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/DIR062-2005.

According to the International Service for the Acquisition of Agri-biotech Applications (ISAAA), Australia's cotton crop, which is almost all 100 per cent GM, comprises 95 per cent of the stacked characteristics herbicide tolerance and insect resistance. See: http://isaaa.org/resources/publications/briefs/43/executivesummary/default.asp.

5 Markets and agronomic issues

Most reports in relation to the marketing and agronomic issues of GM crops have focused on GM canola, however cottonseed as part of the grain-livestock system in Australia was covered in a 2003 report produced by ABARE. Titled, *Market access issues for GM products: implications for Australia*, the report outlines key market access conditions or restrictions that are affecting international trade in GM grains and assesses their impact on trade patterns, such as regulatory arrangements and labelling requirements. Copies of the report are available from: www.daff.gov.au/__data/assets/pdf_file/0011/182828/market_access_gm_crops.pdf.

According to Cotton Australia, the world's main cotton exporters are the USA, India, Uzbekistan, and Australia, and the main exports markets for Australian cotton are China, Indonesia, Thailand, Bangladesh, Korea and Japan. See: http://cottonaustralia.com.au/cotton-library/fact-sheets/cotton-fact-file-the-economics-of-cotton-in-australia.

The Australian Oilseeds Federation (AOF) states that in 2009–10, Australia exported 106,000 tonnes of cottonseed, and Japan and the United States of America (USA) were the key export markets. See: www.australianoilseeds.com/oilseeds_industry/industry_facts_and_figures.

The current and future sampling and testing capabilities for managing the adventitious presence (AP) of approved GM products in non-GM seed and grain in the Australian seed and grain supply chain was addressed in a 2008 report released by the Bureau of Rural Sciences titled, *Maintaining product integrity in the Australian seed and grain supply chain – the role of sampling and testing for GM events*.

According to the report, there are event-specific testing methods available to Australia's trading partners which test for all the GM cotton varieties approved commercially in Australia. One single genetic screen can detect the presence of any of the five approved GM cotton varieties, while a combination of two or more screening assays will provide specific information regarding the exact GM varieties present in any one sample. Copies of the report are available from: www.daff.gov.au/agriculture-food/biotechnology/reports/maintaining_product_integrity_in_the_australian_seed_and_grain_supply_chain/maintaining_product_integrity_in_the_australian_seed_and_grain_supply_chain. www.affashop.gov.au/product.asp?prodid=14196.

A report titled, *Genetically modified crops: tools for insect pest and weed control in cotton and canola* looked at GM insect resistant and herbicide tolerant crops as tools for insect and weed control in Australia and overseas. In relation to the use of insect resistant cotton in Australia, the report found:

- the number of insecticide sprays on GM cotton fields has been reduced
- the amount of insecticide active ingredient used has been reduced
- yield comparisons between 1996 and 2005 showed insect resistant varieties yielded similar levels to conventional cotton
- between 1997 and 2004, the environmental impact of insect-resistant cotton in Australia was 64 per cent lower than the impact of conventional cotton.

According to the report, the Australian experience with herbicide tolerant cottons is that:

- while glyphosate-tolerant cotton requires higher levels of glyphosate use compared to conventional cotton, the increase in glyphosate use is associated with a decrease in the use of other less desirable herbicides
- the environmental impact of herbicide tolerant varieties is estimated to be 15.6 per cent lower than conventional varieties, because residual herbicides were used less
- farmers growing glyphosate tolerant cotton report better control of weeds that are particularly difficult to control in conventional cotton.

The report also concludes that the use of GM cottons had positive social and economic benefits, including decreased occupational health and safety incidents because of the reduction of chemical use and manual weed control in cotton fields; improved community perceptions of the cotton industry because of the altered use of chemicals; reduced spending on insecticides, herbicides and their application; and, it states that most Australian farmers find GM cotton to be more profitable and easier to grow than conventional cotton. For more information: www.daff.gov.au/agriculture-food/biotechnology/pamphlets/fact_sheet_genetically_modified_crops.

6 The science behind GM cotton

Although produced in 1992, a few years before the commercial introduction of the first GM cotton variety in Australia, a CSIRO publication titled *The Science Behind Transgenic Cotton*, remains a good overall background to the science behind the technology, including diagrams, and background to the Monsanto/CSIRO research partnership, resistance management and the safety of any new varieties: www.cottoncrc.org.au/communities/Cotton_Info/The_Science_behind_Transgenic_cotton.

Released in 2002 by the OGTR, this document titled, *The biology and ecology of cotton in Australia:* www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/cotton-3/$FILE/biologycotton.pdf focuses on issues relating to growth and distribution, pests and diseases, weediness, toxicity and gene transfer between cultivated and wild cottons.

7 GM cotton around the world

According to the International Service for the Acquisition of Agri-biotech Applications (ISAAA), 160 million hectares of GM crops were grown around the world in 2011, with GM cotton the third largest GM commodity globally (15.4 per cent of the global GM area) behind soybeans (47 per cent) and corn (32 per cent). Genetically modified cotton was grown in the USA, Brazil, Argentina, India, China, Pakistan, South Africa, Australia, Myanmar, Burkina Faso, Mexico, Colombia and Costa Rica.

The most dominant characteristics in GM crops are herbicide resistance (representing 59 per cent of all GM crops), followed by the combined or stacked traits of herbicide tolerance and insect resistance (26 per cent) and insect resistance (15 per cent).

The ISAAA also reports that GM crops are increasingly offering resource-poor farmers benefits. For example, insect resistant GM cotton was grown by seven million small and resource-poor farmers across more than 10 million hectares in India in 2011. The GM cotton area now represents approximately 88 per cent of the nation's cotton crop. ISAAA states that these farmers benefitted through increased yields and a halving of insecticide applications, and the resulting positive environmental and health implications.

In China the impact of GM insect resistant cotton has also been impressive. In 2011, insect resistant cotton was planted by seven million small and resource-poor farmers on 3.9 million hectares, which is equivalent to 71 per cent of China's cotton crop.

For more information: http://isaaa.org/resources/publications/briefs/43/executivesummary/default.asp.

8 Food

Many people are unaware that cottonseed oil is used extensively for frying by the fast food and take away industry. Cottonseed oil from commercially approved GM cotton varieties has been approved for use in the food chain.

The issue of food safety is often raised as one of the major concerns people have about GM foods. Food Standards Australia New Zealand (FSANZ), have produced a booklet titled, *GM Foods: A Safety Assessment*. The booklet explains FSANZ's role in assessing the safety of GM foods — an assessment all GM foods must undergo before they are allowed to be sold in Australia and New Zealand and is available at: www.foodstandards.gov.au/_srcfiles/GM%20Foods_text_pp_final.pdf.

In December 2001 Australia adopted new labelling laws for GM foods and ingredients. Standard 1.5.2 (food produced using gene technology) ensures that all GM crops, animals and microorganisms must be assessed and approved by FSANZ as safe before they can be used for food or in food processing.

Food products from seven GM commodities may be in Australian supermarkets. These are soybean, canola, corn, potato, sugar beet, cotton and rice.

Food or ingredients labelled 'genetically modified' either contain new genetic material or protein as a result of genetic modification or have altered characteristics, for example improved nutritive values. The labelling rules focus on the end food product, and not the plant or process involved in its production. For example, oil from GM cotton does not require a label because refined oils contain no genetic material, and are identical to oils from a non- GM crop.

For more information:
www.foodstandards.gov.au/_srcfiles/Standard_1_5_2_GM_v106.pdf
www.comlaw.gov.au/Details/F2012C00518.

9 Animal feed

By-products from cotton, including GM cotton are used as a high protein source of animal feed. The use of GM crops as an animal feed source has been investigated extensively around the world.

The research has examined the effect of feeding GM crops to animals on the animals themselves, and also the effects of these crops on animal by-products — such as meat, eggs and milk. The conclusions from these studies were consistent, showing no detrimental effects in livestock fed GM crops or their by-products.

In their issue paper titled, *Safety of Meat, Milk and Eggs from Animals Fed Crops Derived from Modern Biotechnology,* the Council for Agricultural Science and Technology (CAST), concludes:

- Farm animals and humans have a long history of safety associated with the consumption of DNA; consequently, the consumption of DNA from all sources — including introduced DNA in biotechnology-derived crops — presents no health or safety concerns.
- When gene fragments from ingested DNA have been detected in animal tissues/fluids, these fragments are not biologically functional; further, their presence has never been associated with any deleterious effects for animals or with any disruptions of normal animal gene function.
- No plant gene (or gene fragment) has ever been detected in the genome of animals or humans, despite a long history of daily consumption of endogenous plant DNA.
- There is no scientific evidence to suggest that meat, milk, and eggs derived from animals receiving biotechnology- derived crops is anything other than as safe as those derived from animals fed conventional crops.

For more information see: www.cast-science.org/news/?cast_issue_paper_examines_safety_of_consuming_foods_from_animals_fed_biotechnologyderived_crops&show=news&newsID=9881.

The Agricultural Biotechnology Council of Australia Limited (ABCA) has produced a fact sheet on this topic which is available at: www.abca.com.au.

In 2003, the Bureau of Rural Sciences released a report titled, *Tracking Potential GM Inputs to Feedlot Beef — A Scoping Study*, which tracks each crop source for feed used in feedlots, and the potential GM content of these crops, including cotton, field peas, lupins, canola, corn and soybean. It is available at: www.daff.gov.au/__data/assets/pdf_file/0011/182837/scoping_study_gm_feedstuffs.pdf and states that cotton stockfeed may include up to 40 per cent GM content.

The stockfeed industry uses significant quantities of protein meals in their rotations with more than half coming from GM sources, notably soybean meal. The bulk of Australia's soybean meal is assumed to be GM as the majority is imported from the USA. All of the cottonseed meal is also considered to be GM as almost 100 per cent of the domestic crop is planted to GM varieties which are not segregated due to a lack of demand for non-GM cottonseed meal or oil.

See: www.cottonaustralia.org.au and www.isaaa.org

10 GM cottons in the pipeline

In addition to the commercially released GM cotton varieties mentioned, a number of others are currently undergoing field trials in Australia.

Licence no.	Organisation	Modification
DIR115	CSIRO	Enhanced fibre yield
DIR113	Bayer CropScience Pty Ltd	Insect resistance/ herbicide tolerance
DIR101	Monsanto Australia Limited	Insect resistance/ herbicide tolerance
DIR085	CSIRO	Altered fatty acid composition of the cottonseed oil
DIR074	Monsanto Australia Limited	Insect resistance and/or herbicide tolerance
DIR063	Hexima Ltd	Fungal resistance

CSIRO's project to develop cotton with altered oil properties, or high-oleic acid content, is the first commodity GM crop with a consumer-orientated benefit to undergo field trials in Australia. Oil from conventional cotton requires extra processing (partial hydrogenation) to eliminate high levels of polyunsaturated fatty acids, however hydrogenation may increase human cholesterol levels. High oleic acid oils have a healthier fatty acid profile, and are expected to be more stable for frying purposes without the need for hydrogenation.

Further information on all of the above can be found by looking up the relevant DIR at: www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/ir-1.

GM cotton and climate change

A report focusing on the issue of climate change and the potential role of biotechnology in meeting the challenges it may pose for the cropping and pastoral industries of the future was released in 2008.

Titled, *Australia's crops and pastures in a changing climate — can biotechnology help?* the report outlines three main approaches which will help farmers adapt to climate change and reduce greenhouse gas emissions.

1. The development of new varieties:
   - Tools such as molecular markers can provide greater accuracy and speed in conventional crop and pasture breeding programs.
   - Genetic modification techniques provide access to a greater diversity of genes for developing plant varieties with characteristics relevant to climate change adaptation and mitigation.
2. Changing farm management practices:
   - Developing plant varieties which can allow the adoption of farm management practices that are likely to be beneficial under climate change, for example practices such as no-till farming and dry sowing.
   - The development of tools used in many diagnostic tests and in surveillance for plant pests and pathogens which have the potential to detect and identify any new and emerging pathogens which may behave differently under changed climatic conditions.
3. Using alternative crops or pastures:
   - The development of crop and pasture varieties for alternative land uses, such as plants used for biofuels could provide alternative sources of income for farmers whose land had become more marginal due to climate change.
   - Plants could also be modified to produce novel pharmaceutical and industrial products for diversification into new markets.

For more detail: www.daff.gov.au/__data/assets/pdf_file/0005/929588/climate-change-and-biotechnology.pdf.

11 General and other references

Agriculture, Fisheries and Forestry — Australia (AFFA): A detailed report reviewing the testing of GM crops and food products: www.daff.gov.au/__data/assets/pdf_file/0008/196982/AGAL_report.pdf.

Cotton Catchment Communities Cooperative Research Centre, established to enhance the development and growth of the cotton industry through collaborative research (archive only): www.cottoncrc.org.au/industry/crc_home.

Cotton Australia is the peak industry body for Australia's cotton growers: www.cottonaustralia.com.au.

Cotton Research and Development Corporation is a research and industry development partnership between the Federal Government and the cotton industry: www.crdc.com.au.