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Biotechnology and Sugar Research

Resource Guide

This resource explores the biotechnology research being undertaken in the sugar industry, both in Australia and globally. Genetically modified sugar beet is grown commercially in the USA, but there are currently no commercial GM sugarcane varieties grown anywhere around the globe, however, much research is underway, including in Australia, to boost yield, reduce inputs and to develop novel products.

1. CURRENT STATUS

Herbicide tolerant sugar beet is the latest genetically modified (GM) commodity to be grown in the USA. Planted commercially in 2008, the beet was developed by Monsanto, and is resistant to the herbicide glyphosate.

According to field trials conducted in 2007, the GM sugar beet had slightly higher yields and sugar output over conventional varieties. According to a UK study released in 2006, herbicide tolerant sugar beet could also offer a new tool for effective weed management.

Sugar beets are a root crop and they flourish in temperate climates where the growing season is about five months long. In the USA, beets are planted in late March/early April and harvested in late September/October. When fully grown, a sugar beet is about 30 centimetres long, weighs between 900 grams and 2.3 kilograms, and is about 18 per cent sucrose. Sugar beets are grown on approximately 526,000 hectares by about 10,000 farmers in the USA and account for about 54 per cent of the domestic US sugar supply. The remainder is supplied from sugarcane. Sugar beet byproducts include beet pulp, which can be sold for animal feed, and molasses, which is also sold for animal feed or further processed to extract more sugar.

According to the US Sugar Industry Biotech Council, "sugar beet and sugarcane growers throughout North America face significant challenges in protecting their crops from weeds, insects and disease. Biotechnology provides a platform for new technologies to manage these challenges and develop traits, such as new options for weed control, insect protection and disease resistance. Today, biotechnology-enhanced [GM] sugar beets are helping growers manage weeds, improve productivity and lessen impacts on the environment, while preserving a sustainable and geographically diverse supply of sugar."

The sugar from sugar beet and cane is considered interchangeable and is used in candies, cereals, cakes, soft drinks and numerous other products. In order to cut costs, some food manufacturers have moved away from sugar, choosing to use high-fructose corn syrup. The use of imported food products derived from this GM sugar beet has been approved as safe by Australia's food regulator, Food Standards Australia New Zealand (FSANZ).

Genetically modified crops are grown commercially in 23 countries around the world by more than 12 million farmers. Biotechnology, and more specifically, gene technology is being investigated by most of the world's sugar producing countries, including Australia, as a means to improve production in a variety of crops.

2. THE AUSTRALIAN SUGARCANE INDUSTRY

Sugarcane is grown from northern NSW to the far north of Queensland, and 80 per cent of the crop is exported. According to ABARE, Australian sugarcane production is forecast to deliver 4.85 million tonnes (raw sugar terms) in 2007-08, and sugar prices have been buoyed by strong demand for cane sugar and molasses for use in ethanol production, particularly in Brazil, and the prospects of further cuts in sugar beet production in the European Union.

According to ABARE, the challenges and opportunities for the Australian sugarcane industry are:

- Limited expansion potential – the industry is restricted to a coastal strip along the NSW and Queensland coast, and it is suffering from urban encroachment and competing land uses.

- Higher cane yields and commercial cane sugar (CCS) values are the main avenue for future production rises.
- Less producers with larger farms are predicted.

Within the Australian sugarcane industry there is widespread support to develop GM sugarcane varieties with Australian researchers that are ideally suited for local production.

3. CONVENTIONAL BREEDING

All existing commercial sugarcane varieties are hybrids of two species (*Saccharum officinarum* and *Saccharum spontaneum*). Sugarcane breeders have working knowledge of genetic inheritance in sugarcane and use this knowledge to breed superior varieties. However, they could make greater progress towards breeding superior varieties if the genes which account for major variations in key characteristics were identified and plant breeders were then able to utilise these genes in a more targeted way. Biotechnology has the potential to change this through the use of molecular markers. Moreover, the sugarcane industry is using biotechnology research to make the industry more globally competitive through more efficient production and the development of new products for the marketplace.

4. BIOTECHNOLOGY DEFINED

Biotechnology is the use of biological systems — living things — to make or change products. An example of traditional biotechnology in agriculture is cross-breeding different but related crop plants to achieve a desired characteristic, for example disease resistance, and then backcrossing until all the undesired characteristics are bred out with the disease resistance remaining.

Gene technology includes a range of techniques used by scientists to switch genes off or move them between two unrelated species. Using gene technology, scientists aim to introduce, enhance or delete particular characteristics, depending on whether they are considered desirable or not.

5. BIOTECHNOLOGY FOR VARIETY IMPROVEMENT

The use of biotechnology for **diagnostics and genotyping** has implications for quarantine in relation to disease identification, managing disease events and preparing for diseases not yet in Australia. Furthermore, improved techniques in this area have the potential to dramatically reduce the current two year quarantine period in place for intra- and inter-state movement and the use of imported germplasm or varieties.

New techniques for genotyping have positive implications for identifying genetic material which has follow-on benefits for correct labelling of varieties, variety audits and breeding program research.

Molecular markers which highlight the presence and location of useful and detrimental genes are also a tool of biotechnology. They allow breeders to incorporate only useful genes into their breeding programs, and this increases the rate of genetic gain for the entire industry. A number of markers for high sugar content have already been identified. Other markers linked to cane yield and disease resistance are under investigation. Also, researchers are trying to identify the best way to implement markers in the breeding program.

Tissue culture is used to mass produce plants, which are all genetically the same – similar to taking a cutting in your own garden. The key to tissue culture is that the plant regenerates from a single cell back into a whole plant. Tissue culture is done in a sterile environment, and plants are grown without roots on a growth medium that supplies all the nutrients they require. Traditionally, it takes three to six months to get from the initial plant tissue to a small plant ready for potting in sugarcane development, however using a new method called SmartSett®, researchers can produce plants much faster that are less variable.

6. GENE TECHNOLOGY AND AUSTRALIAN SUGARCANE

Australia's national scheme for the regulation of gene technology research came into force in 2001. It aims to protect the health and safety of people and the environment by identifying risks posed by or as a result of gene technology, and by managing those risks through regulating certain dealings with genetically modified organisms. This national scheme is administered by the Office of the Gene Technology Regulator (OGTR).

Crops modified for pest and virus resistance and herbicide tolerance (so-called input traits) represent the current commercially-available GM crops around the world. These characteristics have been bred into soybean, corn, cotton, canola, papaya, lucerne and sugar beet. Of these, only herbicide tolerant and pest resistant cottons, and for the first time in 2008, herbicide tolerant canola, are grown in Australia.

These crops have reduced input costs, provided environmental benefits, allowed growers more flexible management options, and in some cases increased yields. There is no reason to expect that such benefits would not also apply to the sugarcane industry if/when GM sugarcane becomes a commercial viability.

The current GM research involving sugarcane in Australia is represented by the following table.

Research	Organisations involved
Plant growth rate and architecture	• Cooperative Research Centre for Sugar Industry Innovation through Biotechnology (CRCSIIB) • BSES Limited • The University of Queensland (UQ)
High commercial cane sugar (CCS) content	• CRCSIIB • CSIRO • UQ • CSR
Bioplastics	• CRCSIIB • UQ • Metabolix
Biofuels	• Queensland University of Technology (QUT) • Syngenta
Pests	• CRCSIIB • BSES Limited

In relation to the **bioplastic** research, genes from a bacteria have been expressed in cane plants during the research phase, and polyhydroxybutyrate (PHB) can be extracted. Researchers are currently attempting to increase the PHB yield in the plants, and any commercial release is at least five years away.

The most advanced GM sugarcane research in Australia is research which aims to boost sugar production (high CCS content) and is being undertaken by the UQ. The sugarcane has been modified for altered sugar production, and the current trial is assessing the agronomic properties of the GM sugarcane under field conditions to allow researchers to analyse sugar production and quality. The trial forms the basis for future research and development, and possible commercialisation, pending further licence approvals. The industry believes that if successful, this research would increase the profitability and viability of the Australian sugarcane industry in order for it to remain competitive in the global marketplace. Delivery of any commercial varieties is at least five years away.

Despite the fact that any commercial varieties are at least five years away, the Australian sugarcane industry is already considering the potential impacts of GM varieties on other landholders and users of sugarcane products. It is considering the requirements of its customers and consumers and will develop processes to meet their requirements. Like the grains industry, managing the introduction of GM canola in the supply chain, the sugarcane industry wishes to provide choice to producers, the supply chain and consumers. This includes investigating the need for segregation and identity preservation.

7. REGULATORY ISSUES

The OGTR is responsible for human health and environmental safety in relation to gene technology research. A particular focus of the sugarcane industry at this time is a generic understanding of the environmental issues relevant to sugarcane, for example, can an introduced gene crossbreed and express in other sugarcane varieties or with other species?

To date, the industry has:

- Narrowed the list of species compatible with sugarcane
- Identified fertile populations
- Demonstrated sugarcane produces viable seed in some regions

The future priorities for the industry include:

- Determine if there is gene flow from commercial cane to *Saccharum spontaneum,* and from one commercial variety to another
- Determine if seed can establish into mature plants.

8. THE GLOBAL PERSPECTIVE

Brazil is the world's leading producer of sugarcane. Research underway involving gene technology in sugarcane in Brazil, includes herbicide tolerance, pest resistance, high sugar content and drought resistance.

In the **USA**, sugarcane is produced in four states: Florida, Hawaii, Louisiana and Texas. Byproducts of sugarcane processing include molasses and bagasse, the fibrous material that remains after sugar is pressed from the sugarcane. Bagasse is often burned as fuel to help power the sugarcane mills.

Most of the global sugarcane producing countries also grow GM commodities as per the table below.

Sugar producing country	Are GM crops grown commercially, and if so, which crops?
Brazil	Yes. Soybean, cotton.
India	Yes. Cotton.
China	Yes. Cotton, tomato, poplar, petunia, papaya, sweet pepper.
Thailand	No.
Pakistan	No.
Mexico	Yes. Cotton, soybean.
Colombia	Yes. Cotton, carnations.
Australia	Yes. Cotton, carnations, canola.
Indonesia	No.
USA	Yes. Soybean, corn, cotton, canola, papaya, alfalfa, squash, sugar beet.
Philippines	Yes. Corn.
South Africa	Yes. Cotton, corn, soybean.
Guatemala	No.
Argentina	Yes. Cotton, corn, soybean.
Egypt	No.

Source: FAO (2005) and Clive James (2007).

9. SUGAR AND THE ENVIRONMENT

Fermentation is a biotechnology process which has been used for thousands of years in products such as beer, cheese and bread production. Ethanol is a commercial product of fermentation. It is an alcohol produced by fermenting sugar, grain (wheat or corn) or other plant matter using yeasts. All solids and water are removed, leaving pure ethanol. Ethanol, like biodiesel, is a **biofuel**. Biofuels are made from renewable biological feedstocks, either crops or waste, and they are usually blended with petroleum. According to the sugar industry, sugarcane is a more profitable ethanol option than corn or sugar beet.

According to ABARE, Australian sugar mills produce more than 60 million litres of ethanol a year from molasses, which is a byproduct of sugar processing and is mainly used as a high energy feed for livestock. Australia produces enough molasses to manufacture around 270 million litres of ethanol a year. However, ABARE predicts that the livestock feed market will continue to provide the highest returns from molasses production.

Biofuel usage targets vary across countries. Brazil pioneered the widescale use of ethanol for motor vehicle fuel and ethanol production accounts for around half of Brazil's sugarcane production. Brazil also supplies a major part of a growing world trade in ethanol.

The US Government is also funding research into efficient ethanol production, and the goal is to have 30 per cent of fuel provided by ethanol by 2030.

Sugar mills in Australia produce approximately 1100 GWh of **electricity**, equivalent to around two per cent of Queensland's total electricity use. This electricity is derived mainly from bagasse, cane trash and wood residues. The Queensland industry claims that it could potentially supply up to 20 per cent of Queensland's electricity requirements.

The growing emphasis and awareness of alternative fuels, and the development of environmentally friendly energy policies has the potential to influence the profitability and mix of products produced by the Australian sugarcane industry in the future according to ABARE. For example, policies associated with the control of greenhouse gas emissions, including carbon taxes, carbon trading arrangements and minimum renewable energy targets could lead to increased electricity generation from bagasse or cane trash, or increased production of ethanol from molasses and perhaps from sugarcane juices. Credits for carbon sequestered in the form of soil carbon may result in more cane harvest trash being used as on-farm mulch (green cane trash blanketing), rather than being transported to mills to generate electricity.

The Australian sugarcane industry is investing in biotechnology research. Any commercial outcomes are at least five years away. The industry is continuing to review and monitor national and global research and development outcomes to ensure the best results for domestic producers. The sugarcane industry is also monitoring customer and consumer needs and the processes which may need to be in place to meet the product demands of the future.

10. FURTHER READING

Advice on the implications of findings in a Defra-funded desk study: 'Agronomic and environmental implications of the establishment of GM herbicide tolerant problem weeds. 2006. Advisory Committee on Releases to the Environment. UK Government Department for Environment, Food and Rural Affairs. www.defra.gov.uk/environment/acre/advice/pdf/acre_advice78.pdf

American Sugarbeet Growers Association www.americansugarbeet.org/

Australian Commodities. ABARE. March Quarter, 2008. Page 49. www.abareconomics.com/interactive/08ac_march/pdf/ac_march08.pdf

Biofuels FAQ. NSW Government. www.business.nsw.gov.au/PDF/biofuels-biofuel_faq.pdf

Biotechnology in Sugarbeets in Sugarbeet Grower. Tom Schwartz Sugarbeet Grower. 2008. www.sugarpub.com/articles/index.cfm?id=11&section=News&freebie_check&CFID=57280524&CFTOKEN=57851231&jsessionid=88307bf2c4e5483e7360

Cooperative Research Centre for Sugar Industry Innovation through Biotechnology (CRC SIIB) (www.crcsugar.com)

Determination of non-regulated status for Roundup Ready sugar beet. USDA/APHIS environmental assessment and finding of no significant impact. 2005. www.aphis.usda.gov/brs/aphisdocs2/03_32301p_com.pdf

Ethanol from Sugar. What are the prospects for U.S. sugar co-ops? J. Jacobs, Ag Economist USDA Rural Development www.rurdev.usda.gov/rbs/pub/sep06/ethanol.htm

GM Sugar beets Ready for Commercial Launch in 2008 www.teachingscience.org/biotech/knowcenter.nsf/ID/86256AF600621271862573A8005F6046

High Fructose Corn Syrup Use May Be Levelling Off www.ers.usda.gov/AmberWaves/February08/Findings/HighFructose.htm

Official Statement on Biotechnology Enhanced Crops. Sugar Association of America. www.sugar.org/consumers/sweet_by_nature.asp?id=37&fragment=0&SearchType=AND&terms=biotechnology

Sugar Industry Biotech Council (USA) www.sugarindustrybiotechcouncil.org/

Sugar research for a profitable industry. CSIRO Plant Industry. www.pi.csiro.au/enewsletter/pdf/pi_info_sugar.pdf

University of Queensland (UQ) OGTR application www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/dir051-2004

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