

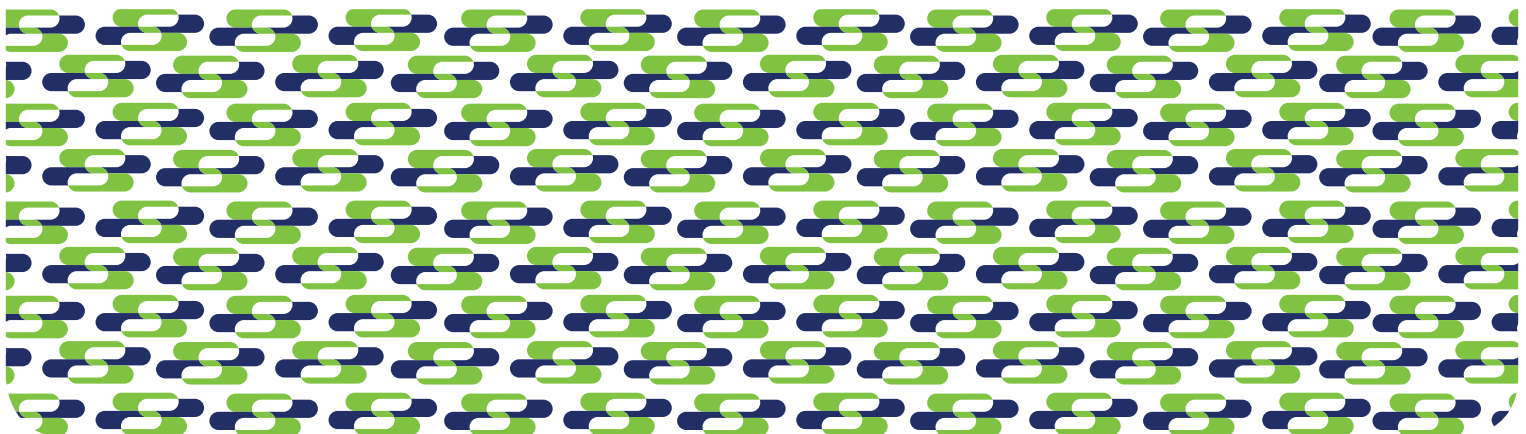


celebrating
SEVEN years of
biotech **research**



Established and supported under the
Australian Government's Cooperative
Research Centres Program

2009-2010 Annual Report



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Vision

Our vision is for a prosperous and sustainable Australian sugarcane industry through the 21st century, generating wealth for Australia as a competitive exporter, and as a key source of biomaterials for new Australian industries.

Mission

Our mission is to combine Australia's strengths in molecular genetics, sugarcane biology, agriculture, and industrial extraction to construct the essential platform of scientific understanding, intellectual property, and commercial linkages that will underpin a value-added sugarcane industry.

Objectives

The Cooperative Research Centre for Sugar Industry Innovation through Biotechnology (CRC SIIB) will seize the strategic opportunity to help develop a sustainable and profitable export-based sugarcane industry, by combining Australia's world-class strengths in molecular biology and chemical engineering with current industry skills and infrastructure.

More specifically, CRC SIIB will:

- provide a sustainable, competitive edge through value-added sugarcane; namely intellectual property (IP)-protected varieties, with reliable high yields of sugar and high-value biomaterials, from environmentally

sustainable farming systems;

- develop novel processes for extraction of renewable biomaterials, and value-add in new downstream industries;
- provide graduates with world-class skills, and seed new strategic partnerships, through which Australia's rural communities can share strongly in the benefits of biotechnology.

Achievements and activities of the CRC in relation to research, commercialisation/ utilisation and education outcomes for the reporting period.

Completion of the strategic research areas identified during our third year review has been the focus of our research activities this past year. The review provided the best opportunity for our CRC to meet our overall research objectives as identified in the original CRC SIIB Commonwealth Agreement.

Research achievements

Our investment in genomics has contributed enormously to the creation of the world's most extensive genomic map of sugarcane (one of the most genetically complex crop species). During the course of our CRC, technologies to support this achievement have been identified and utilised in the construction of the map. At this stage of our CRC (i.e. wind up) the full sequencing of sugarcane DNA is only a short time away. Through our CRC, the Australian sugarcane industry is playing a key role in an international effort to map the sugarcane genome.

Concurrent with this has been a significant effort by our CRC to develop a molecular marker strategy for use in Australia's commercial sugarcane breeding

program. A series of complex markers have been identified and commercialised through the DArTs technology. This marker system was recently initiated in the commercial breeding program and will be the focus of ongoing research into more efficient and effective breeding strategies for the Australian sugarcane industry. In particular, the markers are being applied in the improvement of the parental population.

Our efforts to identify diversification opportunities for the sugarcane plant have continued with the emergence of a major bioactive discovery in sugarcane. In laboratory and more recently, small-scale human trials, the compounds successfully moderated the Glycaemic index value of foods. Originally identified some years ago by our CRC as a potential extract, the key ingredient components and their extraction from sugarcane are proving to be very successful. Now identified as GI Wise™, the extract is one of our key commercial outcomes to be adopted by the commercial company to flow on from our CRC, Sacron Innovations Pty Ltd.

Our continued investment in the expression of commercially viable levels of biodegradable plastic PHB (polyhydroxybuterate) has resulted in potential new opportunities for Australian sugarcane and for 'greener' plastics into the future. Identification of key steps in the chemical pathways within the plant organs has enabled innovative opportunities to



increase PHB expression levels beyond our original expectations. Complementing studies have led to the creation of a world-first metabolomics study in sugarcane.

The world's attention on using the sugarcane plant as the basis for plant-based expression of industrial products, as well as the development of input-based GM sugarcane (i.e. drought resistance, nitrogen efficiency etc), has required a far better understanding of the basic biology of sugarcane. Our CRC has funded research into understanding gene flow between sugarcane varieties and between sugarcane and closely related species of grasses. Studies in this area have been the basis of international collaborations and visits over the last 12 months. In full cooperation with Australian regulatory groups, research results now provide the world with a much better understanding of the flowering and potential weediness of sugarcane. The



information will be used in national and international arenas to assist in the deregulation of GM sugarcane events.

Our CRC's commercialisation program has continued to identify strategic commercial partners to carry our research outcomes forward to commercialisation. These alliances now having us testing Barrecote™ in Australia, USA and Europe. Barrecote™ is a fibre extract which provides the basis for a waterproofing treatment for paper. As a replacement to wax, the technology provides a recycling capability for treated

paper not available when waxes are used as the waterproofing agent. Barrecote™ will be one of the first major products to be managed by Sacron Innovations Pty Ltd.

Education outcomes

Two aspects of the CRC's Education Program have continued to attract significant interest.

The training efforts of our 30 postgraduate students have progressed well. Our students have made a major contribution to the scientific publications

of the CRC over the last seven years and, in particular, have been significant authors to five of the seven patents filed by the CRC.

Our investment in educational research into the development and understanding of teaching techniques and the effectiveness of biotechnology teaching modules attracted a great deal of attention both here and overseas. The PhD staff involved have been sought after in terms of delivering the key findings of their work to many international education forums.

Executive Summary (cont'd)

Our CRC
has created
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markets ...

Risks, opportunities and responses to the above.

The CRC R&D portfolio has given rise to (currently) six patents which are now being commercialised by the CRC IP Company Sacron Innovations Pty Ltd. This commercialisation process involves significant levels of further investment and a continuing risk of commercial failure. However, based on the reaction from the global market place the opportunities created by the technologies are even more significant and promising.

For the remainder of the CRC, IP will become platform technologies and background IP to many on-going projects undertaken by the CRC Participants.

Impediments to achievement of the CRC's objectives experienced during the year and strategies adopted to address these.

As reported in 2008/09, the challenge to double the value of the Australian sugarcane

industry remains unlikely. Our CRC has created a number of technologies with significant global markets that are now under consideration. In terms of the long-term profitability of these new technologies, the value proposition for Australia remains in global adoption.

2009/10 Highlights


- > Development of the world's most extensive sugarcane gene map.
- > Application of the first ever molecular marker system (based on DArTs) to the Australian sugarcane breeding program.
- > Research that shows new sugarcane-based bioactive proves highly effective at reducing GI.
- > Expression of PHB levels (biodegradable plastics) reaches higher-than-expected levels.
- > A world-first study into weediness of sugarcane study that will help with the future safe release of GM sugarcane
- > Commercialisation that achieves enormous national and international interest in recyclable paper coating, Barrecote™.
- > Specialised biotechnology education project with strong interest both here and overseas.

CRC SIIB activities and achievements to date cover two national research priority areas. These include transforming the existing sugar industry through development and implementation of biotechnology-based opportunities to produce more sugar, and development of novel business opportunities to provide diversity across the industry's small number of commodity products.


Our investment continued in molecular markers to help deliver new varieties through conventional breeding to provide an opportunity to reduce the development time of new varieties and help focus breeding selection on delivering specific traits required by the industry. Further, the CRC is investing in biotechnology applications which will provide the industry with environmentally sustainable production systems using better fertiliser and pest management.



AN ENVIRONMENTALLY SUSTAINABLE AUSTRALIA – Transforming the way we use our land, water, mineral and energy resources through a better understanding of environmental systems and using new technologies


 Water - a critical resource


PROMOTING AND MAINTAINING GOOD HEALTH – Promoting good health and preventing disease, particularly among young and older Australians

 A healthy start to life

FRONTIER TECHNOLOGIES FOR BUILDING AND TRANSFORMING AUSTRALIAN INDUSTRIES – Stimulating the growth of world-class Australian industries using innovative technologies developed from cutting-edge research

 Frontier technologies

 Advanced materials

 Smart information use

Governance & Management

The CRC SIIB is headed by a Governing Board including nominees of the main participating organisations, with most Board Members drawn from industry participants or intended users of CRC outputs. The Board is headed by an independent Chairperson.

Board membership includes individuals with exceptional experience and insight into scientific research, research management, commercialisation, the sugarcane industry, development of new industry opportunities, education and community relations. The Chairperson and most Board

Members have previous board experience and a record of commitment and success in ensuring the work of complex and collaborative organisations, such as the CRC, is on target. The Board is responsible for setting policy and resource allocation to maximise CRC achievements.

CEO & Governing Board Members and Committee Members

Dr Annette Sugden assumed SRDC representation on the CRC Governing Board following the resignation of Dr Frikkie Botha in December 2009.

Name	Organisation	Position/Role
R J Clements	Independent	Chair of Board, C-SIIB Management, and Sugar Industry Innovation (private sector)
E S Wallis	BSES Limited	Board, Chair - Audit Committee
J Burdon	CSIRO	Board
S Williams	SCU	Board, Member Audit Committee
F Botha (1 Jul - 31 Dec 2009)	SRDC	Board, Member Audit Committee
A Sugden (1 Jan - 30 June 2010)	SRDC	Board
J Mott	UQ	Board
I McMaster	Independent	Board, Member - Audit Committee (private sector)
A Cristaudo	Independent	Board (private sector)
P H Twine	CRC SIIB	CEO, Board member, Managing Director of C-SIIB Management and Sugar Industry Innovation.
D Goosen	CRC SIIB	Director of C-SIIB Management and Sugar Industry Innovation.
D Munro	Independent	Board Secretary and company secretary to C-SIIB Management and Sugar Industry Innovation. (private sector)
D Theriault	Dow Chemical Company	Observer - Board (private sector)
D Henderson	Uniquist	Director of C-SIIB Management

Board Member Skills

R J Clements	MAICD, 20 years Board experience, Research Management, International Agricultural research Collaboration
E S Wallis	20 years Board Experience, Research Management
J Burdon	Research Management
S Williams	Research management
A Sugden	Research Management
A Cristaudo	Canegrower, Sugar Industry representation
I McMaster	CEO CSR Sugar, commercial and corporate governance experience, Chairman Public Company
P H Twine	MBA, MAICD, 14 years Board experience, Research Management

Board Meetings

Meeting #	Date	Apologies
27	17 July 2009	Botha, Cristaudo, Williams
28	4 September 2009	No apologies
29	4 December 2009	Cristaudo
30	26 February 2010	No apologies
31	21 May 2010 (teleconference)	Cristaudo
32	4 June 2010	No apologies

Program Leaders

Title and name	Organisation	CRC Position/Role
J Manners	CSIRO	Program Manager (Program I)
L Nielsen	UQ	Program Manager (Program II)
P Schenk	UQ	Program Manager (Program III)
D Goosen	CRC SIIB	Program Manager (Program IV)

Changes to Participants

As part of the Wind Up process Dow AgroSciences chose not to become shareholders to the CRC succession company Sacron Innovations Pty Ltd. To this end the Wind Up process included an agreement amongst the parties to the Centre Agreement to retire them from the Unincorporated Joint Venture as at 30 May 2010. As a consequence their Trust Unit holdings in the IP Trust were cancelled and they have no shareholdings in Sacron Innovations as at 30 June 2010.

Participant's Name	Retiring or New	Commonwealth Approval Y (Yes) N (No)
Dow AgroSciences	Retiring (30 May 2010)	N

Structure & Management



Our investment in genomics has contributed enormously to the creation of the world's most extensive genomic map of sugarcane ...

Structure & Management (cont'd)

The management structure for this CRC is an unincorporated joint venture, supported by two companies with specific roles in IP and commercial management, under the direction of the governing Board.

The IP Trust Company holds legal title to the IP arising from CRC research, and can enter

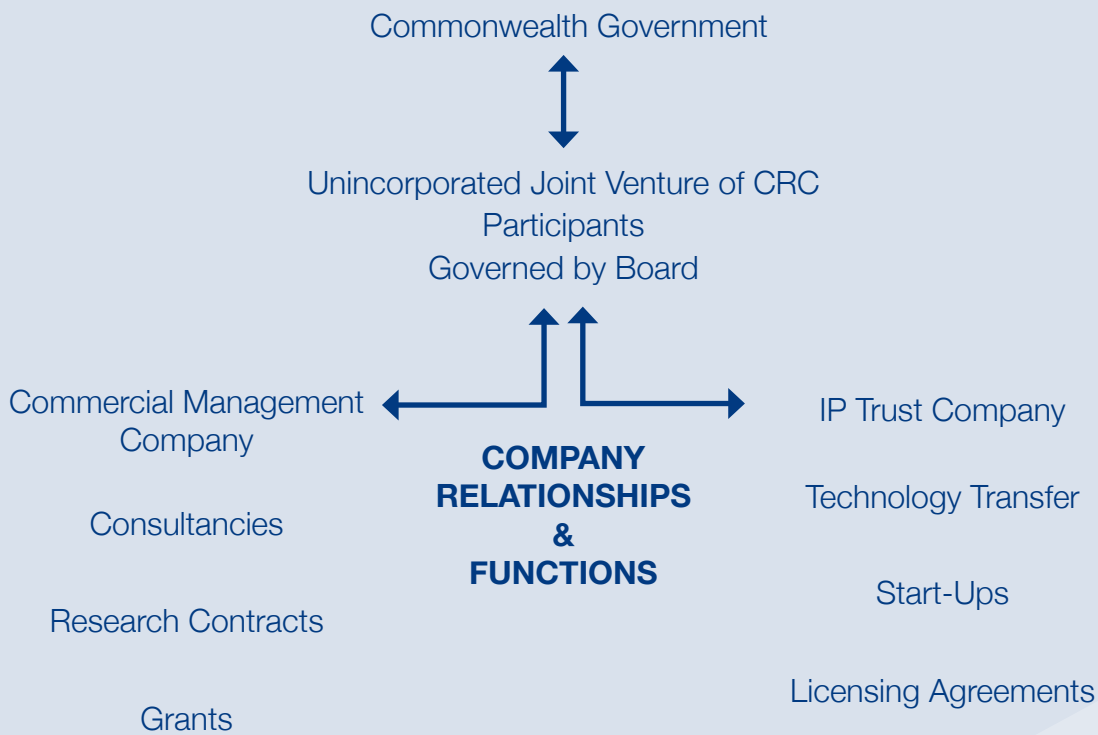
into agreements with other parties, including licenses for commercialisation.

The Commercial Management Company is the legal entity through which the CRC enters into agreements with third parties such as granting bodies and research contractors. This structure gives best resolve to

the overall corporate governance of the CRC, allows appropriate involvement of industry participants in commercialisation of CRC outcomes, provides employment flexibility for participants and provides a single negotiating party for external contracts.



Structure & Management (cont'd)



Research & Development Portfolio



The Cooperative Research Centre for Sugar Industry Innovation through Biotechnology's (CRC SIIB's) current project portfolio is organised under four programs.

The programs are designed to create the most opportunities for our research to add significant commercial value to the Australian sugarcane industry.

They are:

Enhanced sugarcane farming systems

- Environmental Sustainability
- Marker Development and Implementation

New product development from sugarcane

- Sugarcane as a Plant Biofactory
- Value-adding Biorefineries

Technology transfer (Commercialisation and Utilisation)

- Communication

Education

Project Milestones



Outcome	Output	Milestone	Milestone Delivery Date	Is Active	Achieved
1. Increased and more environmentally sustainable sugarcane production underpinning a profitable sugar industry.	1.1. Gene technologies and breeding tools for enhanced sugar concentration and sugar yield from sugarcane	1.1.8. Generation of sugarcane genotypes with enhanced sucrose accumulation and sugar yield through application of above technologies for use in sugarcane improvement program.	30 Jun 2010	Yes	Yes
<p>DETAILS/REASON: As reported in the previous milestone none of the specific sugar accumulation traits studies has proved appropriate for further development. The novel IP created in the conduct of the work has been re-evaluated and deemed inappropriate for IP protection at this time. The program has increased considerably the understanding of some of the genetics of the sugar accumulation controls. As reported in the previous milestone none of the specific sugar accumulation traits studies has proved appropriate for further development. The novel IP created in the conduct of the work has been re-evaluated and deemed inappropriate for IP protection at this time. The program has increased considerably the understanding of some of the genetics of the sugar accumulation controls.</p>					
	1.2. A sustainable sugarcane production system using gene technologies.	1.2.7. Biotechnologies for reduced environmental impact in sugarcane farming systems developed and tested and transferred to industry.	30 Jun 2010	Yes	Yes
<p>DETAILS/REASON: The traits considered under this commercial-in-confidence project have now provided information for consideration of an IP position. This position will be considered by the CRC follow-up IP company (Sacron Innovations).</p>					
	1.3 An enhanced sugarcane breeding program producing superior sugarcane varieties through the application of biotechnology.	1.3.7. Breeding program has integrated marker technology with measurable improvements in genetic gain.	30 Jun 2010	Yes	Yes
<p>DETAILS/REASON: The key outcome of the significant CRC investment in markers for sugarcane breeding has been the initiation of the use of these molecular markers to improve the value of the parents used in the Australian sugarcane breeding program. The CRC DArTs technology commercialised in 2008 now provides the basis for this technology. Data from the investment has also identified a specific group of markers which identify the majority of the sought after commercial value sought by the current breeding program. These markers are being developed onto an amended DArTs chip for subsequent commercialisation.</p>					
2. A combination of co-products, alternative products, and downstream products that double the economic return per hectare of sugarcane within 10-15 years	2.1. IP-protected enabling technologies for: (a) expression of novel and useful genes in desired patterns for sugarcane improvement; (b) stability and activity of introduced gene products in the required cellular and subcellular compartments for metabolic engineering in sugarcane; and (c) extraction and downstream processing of value-added materials from sugarcane	2.1.7. (a) Integration of technologies for optimal value capture from sugarcane grown as a co-production system for multiple biomaterials and precursors for downstream value adding; and (b) platform technologies integrated with relevant product streams.	30 Jun 2010	Yes	Yes
<p>DETAILS/REASON: A range of technologies have now been identified and tested for significantly improving the expression of bio-materials in sugarcane. The IP created in the course of the work has also been identified and protected and has been licensed to the commercial partner. The range of bio-materials created will be a function of the current and future marketplace acceptance and demand for this range of products.</p>					

Outcome	Output	Milestone	Milestone Delivery Date	Is Active	Achieved
	2.2. Sugarcane varieties engineering for biosynthesis of high-value products in addition to sucrose, or as alternatives to sucrose.	2.2.6. (a) Improved varieties selected with commercial yields of high-value biomaterials. Pilot scale harvesting, extraction and market development; and (b) commercial partnerships developed for commercial-scale testing of new bio-production system.	30 Jun 2010	Yes	Yes
DETAILS/REASON:: Sugarcane genotypes are now available with near commercially acceptable expression levels of the target compound. A range of technologies have now been developed to increase these levels further and the IP position appropriate to the technologies have been identified and protected. Commercial scale extraction processes remain premature to the current status of the work.					
	2.3 New product classes developed for production in the sugarcane biofactory.	2.3.7. Field evaluation, development of extraction technologies.	30 Jun 2010	Yes	Yes
DETAILS/REASON: A range of other biomaterials in the form of bioactives have now been isolated and identified from sugarcane parts. Extraction methodologies have also been identified and will form the basis of ongoing purification and commercialisation of the extracts. A program of work is being developed to continue this work through the IP commercialisation company (Sacron Innovations) and with input from one of the commercial participants.					
	2.4. Processes for conversion of materials from sugarcane into higher-value products through downstream processing in collaboration with the sugarcane industry.	2.4.7. Process design and scale-up in collaboration with partner mills.	30 Jun 2010	Yes	Yes
DETAILS/REASON: No new progress has been made in this aspect of the program pending the decision by the commercial partner to go to the next step in the commercialisation. In the meantime a scale up series of experiments are being designed and planned for the application of Barrecote to paper at an Australian paper mill .					
3. (a) The education of students, staff and industry sector personnel in plant biotechnology to seed new strategic partnerships through which Australia's rural communities will share strongly in the benefits of biotechnology; and (b) assessment of sugar industry stakeholders' awareness and attitude to GMOs and biotechnology.	3.2. Enhanced industry capacity to respond to new opportunities in plant biotechnology and enhanced community awareness of plant biotechnology.	3.2.7. Plans for continued education and communication packages beyond 2010.	30 Jun 2010	Yes	Yes
DETAILS/REASON: A range of teacher and student education packages have now been developed and are ready for release to Australian schools based on CRC SIIB research examples of biotechnology in sugarcane.					
4. A capacity to interact with industry groups (growers, manufacturing sector) in the development and delivery of effective R&D to meet the challenges of commercialising new value-added rural industry products based on sugarcane.	4.1. New knowledge-based, profitable and sustainable rural export industries. Public benefits will also be provided through new regional spin-off industries allowing our rural and regional communities a greater share of the benefits of biotechnology.	4.1.7. Commercial development underway.	30 Jun 2010	Yes	Yes
DETAILS/REASON:: Both Barrecote (a bio-based and recyclable waterproofing treatment for paper and GI Wise, a sugarcane extract which significantly lowers the Glycaemic Index value of foods are now in commercial scale development.					
		4.1.8. CRC technologies delivered to end users.	30 Jun 2010	Yes	Yes
DETAILS/REASON: The CRC IP (5 patents, germplasm and trade secrets) will now be passed to Sacron Innovations, as a commercially focussed and participant owned company whose mission is to continue the commercialisation process for the more mature and near to market technologies developed within the CRC program of work.					

A photograph of sugarcane plants growing in a greenhouse. The plants are tall with long, green leaves and white stalks. The greenhouse structure is visible in the background.

Program One

**ENHANCED
SUGARCANE
FARMING
SYSTEMS**

ENHANCED SUGARCANE FARMING SYSTEMS

Program One focused on three target areas in sugarcane biotechnology research and development. These areas included:

1. The application of biotechnology to minimise the Australian sugarcane industry's environmental footprint.
2. The development of new breeding technologies to accelerate the delivery of new, more profitable sugarcane varieties.
3. Research into the adoption of new GM varieties and the effective integration GM traits into Australian sugarcane breeding programs.

(The third target area included work by our CRC to provide a basis for the assessment of the environmental safety of future GM sugarcane releases.)

The CRC SIIB has enabled multiple institutions to work together on these target areas of research. The CRC SIIB team not only made great progress in these areas, several significant milestones were reached. Towards the future, further research, development and commercialisation will be necessary to convert these program outputs into industry outcomes.

To achieve long-term benefits the philosophy of this program has been to support short and long-term research goals. As it takes 10 years to breed new sugarcane varieties, this program did not have the capacity to create

technologies for immediate uptake. More importantly, the impact on the Australian sugarcane and supporting industries of the outcomes of Program One will be profound and will stand the test of time.

Biotechnology to reduce the environmental footprint of sugarcane production

The Australian sugarcane industry is located in a highly environmentally sensitive area adjacent to the Great Barrier Reef and other natural features of significance. Additionally the industry shares its waterways with local communities and other industries.

2009/10 Highlights

- > Great progress was made towards understanding the biology of sugarcane and its relatives to identify environmental hazards that need investigating to allow science-based evaluation of the release of GM sugarcane.
- > Research outcomes showed that improved sugarcane varieties combined with alternative N fertiliser management strategies may increase N acquisition and reduce required N inputs and potential losses from sugarcane farming system.
- > Transgenic plant lines with a series of valuable input traits were generated and successfully established in a trial as part of the novel pest resistance work.
- > Promising DArT-based markers for high biomass were screened to improve gene map coverage. Individual markers with significant associations to biomass levels in the original population are being scored in a second generation of plants to examine repeatability.
- > Great progress was made towards the development of a sugarcane genome map. Sequencing of genomic DNA generated more than 20 billion base pairs of sequence to date.

Program One (cont'd)

The Queensland State Government enacted the Reef Protection Program to regulate the use of pesticides and fertiliser in sensitive areas. While sugarcane growing targets are currently managed by agronomic practices, in the long-term it is hoped that new sugarcane varieties will help minimise pesticide and fertiliser applications. It is most likely that biotechnology will play an important role in helping to breed these new varieties.

During the past seven years, this program has researched the development of a bioremediation technology with the potential to degrade atrazine residues in the environment. More recently, research involved work with

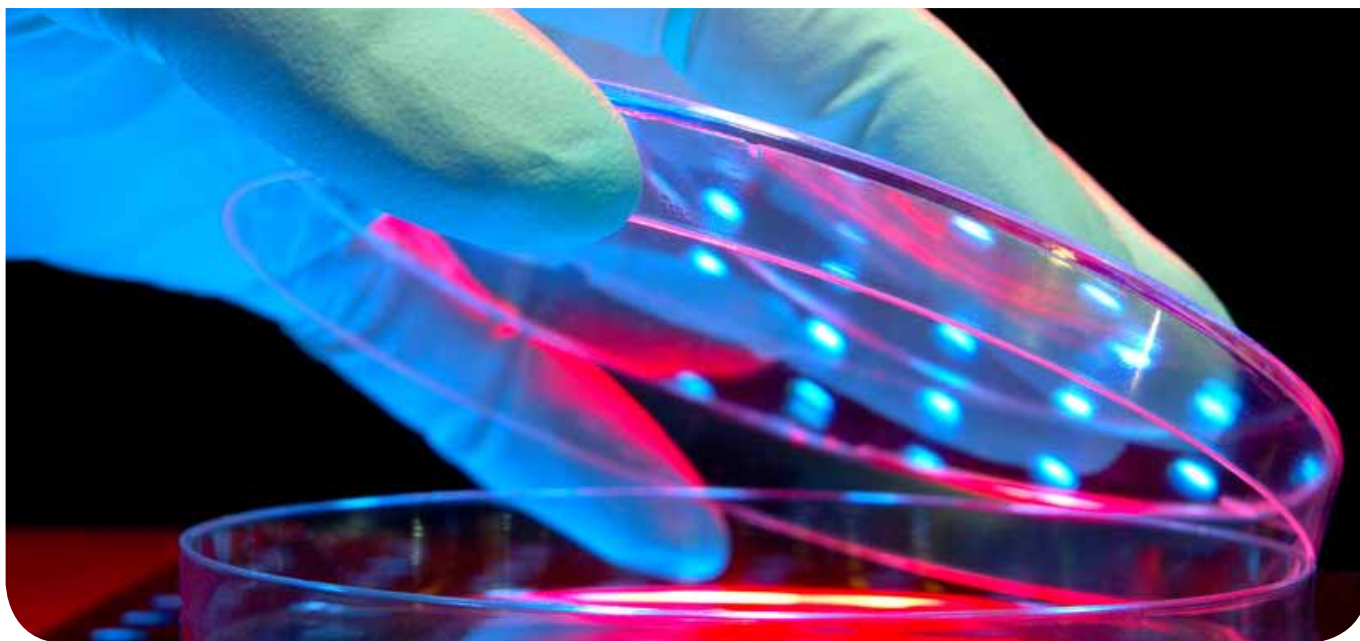
DOW AgroSciences to test gene technologies for the control of nematode pests in transgenic sugarcane. If this work leads to new varieties, it will reduce the current rate of nematicide application by industry.

Both of these technologies will require further development and testing after the CRC. If technically successful, their commercial viability will need to meet the rigours of the marketplace and regulatory system.

A major contribution of this program has been understanding nitrogen (N) utilisation by sugarcane. Our work has rewritten the text book for N assimilation in sugarcane by showing clear physiological

differences with other grasses. This new knowledge is important because in most sugarcane production soil systems, applied urea fertilisers break down to ammonia which in turn undergo biological nitrification to eventually form nitrate. An additional source of nitrogen comes from amino acids released from soil organic matter, especially from the green trash blankets of previously harvested crops.

Early research in this program showed that sugarcane varieties strongly prefer amino acids and ammonia over nitrate. This is unfortunate because nitrate leaching into waterways and conversion of nitrate to the potent greenhouse gas nitrous oxide



Australia has had a dynamic and world-leading sugarcane breeding program.

are two of the most potentially undesirable environmental consequences of sugarcane farming. These undesirable effects could be more easily reduced if plants that use nitrate more efficiently were readily available.

Most of the CRC's understanding of N assimilation has come from physiological studies with maize, a widely studied crop plant. However, unlike maize that can take up and store nitrate, sugarcane does not accumulate nitrate in its vegetative tissues. Unfortunately it is not possible to cross maize and sugarcane to breed these traits into commercial sugarcane varieties, but encouraging results have been obtained with other wild relatives. Indications are that members of the genus *Erianthus* are also able to assimilate nitrate in the presence of competing N sources, such as ammonia, much more efficiently than other species. Collaboration with Chinese scientists has shown that the wild grass *Erianthus rockii* can be crossed with sugarcane. This opens the way to introduce these genes into commercial breeding germplasm.

The whole process may take several years to complete but these discoveries indicate that development of sugarcane varieties that can reduce damaging nitrate pools in the soil and increase yield returns from costly fertiliser inputs are a real possibility.

New sugarcane breeding biotechnologies

New innovative biotechnologies can be delivered to growers via improved sugarcane varieties. New Varieties represent one of the most readily adopted forms of technology in the Australian sugarcane industry. The maintenance and growth of the industry's production base is reliant on a high-performing delivery pipeline of new varieties with better adaptation, stress tolerance, disease resistance and optimised yield. For a long time, Australia has had a dynamic and world-leading sugarcane breeding program. The adoption of molecular tools represents one of the next technological innovations that will keep this program at the head of the field.

The initial achievement of the CRC in delivering molecular biology to sugarcane breeding was the development of the DArT marker chip and a fee-for-service arrangement for delivery of this genome analysis tool with DArT Pty. Ltd. in Australia. This program has since worked intensively on using DArT and other marker technologies for the discovery of DNA markers that can be used as surrogates for selecting genotypes that carry important traits.

A major strategy in this marker discovery activity has been to use association genetics. This is where specific markers can be identified from large populations associated with genotypes

that carry a particular trait. In this approach the program has been able to tap into large industry databases on the field performance of individuals in these populations. Careful statistical analyses have been developed to ensure that the genomic region responsible for the trait and the marker are linked (i.e. exist on the same chromosome) and are not simply derived from coincidental co-inheritance of traits and markers resulting from recent common parental ancestry in the population.

This work has resulted in a suite of markers that explain highly significant proportions of sugar content, yield and diverse disease resistances. The team's modelling of how and when markers could be applied in the breeding process (including cost estimates of marker analysis) has resulted in a strong recommendation that the initial application of markers be made in a rapid parent improvement process. The result will be parents highly enriched in desirable DNA code from which elite progeny can be conventionally selected in stages.

The long time frames that are required for sugarcane breeding mean it is important to look over the horizon at traits that may have greater importance in the future and begin to lay a foundation for the introduction of these traits. Renewable energy is seen as an important component in the measures taken to



mitigate against future climate change and the cogeneration of electricity is already an important feature of several sugar mills in Australia. Policies such as the 'Carbon Pollution Reduction Scheme' (now in abeyance) and more recently the Renewable Energy Target Legislation provide a platform to build further cogeneration ventures. Internationally there is increased effort going into the development of technologies for the fermentation on lignocellulose for the production of biofuels.

Economically viable processes for this would offer alternative avenues for the commercial exploitation of bagasse.

All of these trends point towards sugarcane fibre having an increased value in the future. Some future sugarcanes may simply be feedstocks for fermentation and energy generation, better termed 'Energy Canes' rather than the current-day sugarcanes dedicated to the crystal sugar business.

The CRC SIIB has been involved in the development of high

biomass canes that might fit such future energy production systems. These canes will take full advantage of new gene pools from unexploited *Saccharum spontaneum* accessions and *Erianthus spp.* Currently and into the future, these new energy canes will be tested through the Australian sugarcane industry's Joint Venture for new agronomic characters of value, but early tests indicate that they have the potential to produce extraordinary biomass yields, fermentables and fibre.

While DNA markers have been essential in the characterisation of these potential energy canes a study of the chromosomes of crosses of *Erianthus* into sugarcane backgrounds has indicated that chromosomal recombination is either precluded or is rare, while chromosome addition lines can be generated. It is hoped that arrangements can be established to enable these lines to be tested in the coming years for the presence of useful traits from *Erianthus*, such as water-use and nitrogen-use efficiency, and to tie these traits to specific chromosomes for future breeding.

Finally, a highly pre-competitive area of sugarcane research of international importance is the complete explanation and mapping out of the sugarcane genome sequence. Even though important progress has been made in several other crop genome sequences, including relatives such as sorghum and maize, it is the polyploid nature of the sugarcane genome that makes the goal so unique.

The high polyploidy of sugarcane foils the assembly process used for most genome sequences (i.e. where alike sequences are aligned by overlap). This presents enormous technological challenges. The scientific value in this endeavour may be a greater understanding of how polyploid genomes function and, for sugarcane in particular, how this may be associated with plant vigour and performance.

Polyploid plants are common in nature and this will have impact beyond the *Saccharum* genus. So far the CRC SIIB has allowed Australian researchers to sit at the table of a large international consortium to tackle the sugarcane genome, and some syntony with sorghum has been delineated. The sequencing of the section of the sugarcane genome of specific interest to Australia has been achieved.

If we could take a look over the science horizon into the future, plant, animal, microbe and human genetics will be dominated by genome-based technologies. Access to the first and subsequent sugarcane genomes will enable the discovery of new markers, genes and genetic interactions that will also impact on future breeding and cultivar performance.

Facilitating science-based regulation of future gm sugarcane

To date, there has been no commercial release of genetically modified (GM) sugarcane in Australia or elsewhere. The rapid growth of the Brazilian sugarcane production system in the past decade and the prospect of another decade of continued growth has now attracted the interest of several of the large multinational companies that commercially exploit GM technology in other crops. It is very likely that the first GM traits that are released in sugarcane

will be the same genes and gene combinations that have been successfully developed in crops such as maize.

It is important that Australia maintains at least technological parity internationally in these developments to be competitive in its markets. One attraction of the Australian system is that it has a well defined, robust, transparent and science-based regulatory system for GM products. The CRC SIIB has added to this reputation by funding research aimed at providing data to underpin a regulatory framework that may be used to assess the environmental safety of GM sugarcane releases.

This work has involved the assessment of outcrossing to weedy relatives of sugarcane and the potential for seed set and establishment. Similarly the factors of pollen spread and cross-fertilisation between sugarcane varieties has been established. Interestingly, a series of studies were also undertaken in Panama (as part of a Smithsonian Fellowship) where *S. spontaneum* is an invasive weed. The genotypic/environment interactions that make *S. spontaneum* a successful weed in Panama, but not in northern Australia, were determined.

The outcomes of this work do not preclude the release of GM sugarcane. It will be necessary to assess the risks associated with specific GM traits that are contained in future proposed releases. This work has been the

Program One (cont'd)

first in the world to address these important questions and has provided scientific evidence for informed regulatory decisions in Australia.

PROJECT OUTCOMES

Managing the safe release of genetically enhanced sugarcane

The project made great progress towards understanding the biology of sugarcane and its relatives to identify environmental hazards that need investigating to allow science-based evaluation of the release of GM sugarcane.

During 2009/10 a third season of field observations were collected in northern Australia and data were obtained for more southerly regions. A base line for the frequency of flowering of commercial crops and populations of *S. spontaneum* (a sexually compatible relative of sugarcane) and the timing and levels of viable seed production has been established.

A series of studies were also undertaken in Panama (as part of a Smithsonian Fellowship) where *S. spontaneum* is an invasive weed. The genotypic/environment interactions that make *S. spontaneum* a successful weed in Panama, but not in northern Australia, were determined.

Laboratory analyses to determine the level of crossing in commercial sugarcane fields and how far pollen travels are being completed. Publications for submission to international peer-reviewed journals are being prepared. The projects' findings were also discussed in April 2010 with Government agencies that regulate GM technologies in Australia.

Final outcomes from this work are being generated by providing the information to the designated regulatory authorities in Australia and internationally and also by publication of our results. Ultimately, the information is available for on-going use to inform decisions about the future release of genetically modified sugarcane in Australia.

Reducing plant nitrogen demand

The acquisition of nitrogen (N) by plants is a key component of nitrogen use efficiency. The CRC SIIB nitrogen use project examined the concept that nitrate is the main N source for sugarcane by comparing use of inorganic (ammonium, nitrate) and organic (amino acids) N forms, all of which are prevalent in Australian sugarcane soils.

Analysis of growth and metabolite profiles has demonstrated that sugarcane uses organic N as a N source in sterile and in glasshouse conditions, and field-grown sugarcane readily takes up organic N. Further, our research

trials have shown that organic N modifies root structure which has potential benefits for plant access to water and soil nutrients.

By examining the root structure of many sugarcane genotypes, our research team identified the potential for manipulation of root systems through breeding.

This research has shown that improved sugarcane varieties combined with alternative N fertiliser management strategies may increase N acquisition and reduce required N inputs and potential losses from sugarcane farming system.

Novel approach to improve pest resistance in sugarcane

The CRC SIIB novel pest resistance project is a proof-of-concept project to demonstrate a transgenic approach to controlling sugarcane pests.

Significant achievements were made during 2009/2010 with the generation and multiplication of transgenic plant lines with a series of input traits. Over three hundred transgenic plant lines expressing the traits at different levels were selected for screening for pest resistance across twelve bioassay experiments. Eight of these bioassay experiments were harvested and analysed.

Pest resistance levels in nineteen promising plant lines identified in the first six bioassay experiments were reassessed in a validation trial that will be harvested in June

2010. Only through validation of the resistance levels in the promising plant lines will we have insight into which of the traits are effective in providing sugarcane plants with resistance to the target pest.

Transgenic material identified through this work may be incorporated in elite future sugarcane varieties to provide specific pest resistant traits.

High biomass sugarcane

The project has involved following up on CRC SIIB research results that suggest some large quantitative trait loci (QTL) effects for biomass yields in a population of sugarcane recently derived from the wild cane species *S. spontaneum*.

Additional DArT-based markers were screened in this population to improve gene map coverage, and individual markers with significant associations to biomass levels in the original population are being scored in a second generation of plants to examine repeatability. Some of the sugarcane clones in the study have achieved high yields and could have commercial value.

Final recommendation from this work will detail methods for Australian sugarcane breeding programs to cost effectively undertake marker assisted selection for high biomass varieties. This may include specific markers and optimal selection indices. Final

recommendations will also apply to other high-value populations identified in future commercial exploitation of potentially high value cross populations in Australian sugarcane breeding programs.

Marker assisted breeding

The aim of this project is to help facilitate the adoption of marker assisted breeding in the Australian sugarcane breeding program based on CRC SIIB research.

A suite of agronomically important markers have been identified. These markers were selected using several statistical models and represent the current group of markers most likely to produce the best outcomes. These markers will be used in conjunction with a rapid DNA sampling and extraction method that was developed by DArT.

CRC SIIB modelling suggests that at the current estimated operation costs for these markers, application of DNA markers in a 'Marker assisted recurrent selection program' for rapid improvement of parental breeding value, will increase rates of genetic gain in sugarcane breeding programs. Plans to test such a selection program have started as part of the BSES-CSIRO sugarcane breeding program.

Complete genome map of sugarcaneThe aim of this project

is to deliver valuable information on the location of potential genes involved in traits of economic value.

Sequencing of genomic DNA from sugarcane genotypes has generated more than 20 billion base pairs of sequence to date. An enrichment experiment has been designed using the sorghum genome sequence and selected additional sugarcane specific sequences. This will allow detailed and invaluable sequencing of the gene rich regions of the sugarcane genome. Furthermore, sequencing of the parents of mapping populations will reveal large numbers of polymorphisms and provide markers linked to most genes in the genome.

The CRC work now forms part of an International Sugarcane Genome effort to sequence the complete genome. To this end a workshop was held in Port Douglas in August, San Diego in January and another meeting of the sequencing consortium is planned for August 2010 in France.

Program Two

**NEW PRODUCT
DEVELOPMENT
FROM
SUGARCANE**



NEW PRODUCT DEVELOPMENT FROM SUGARCANE (BIOPRODUCTS)

Recent research into producing high-value biomaterials from plants has confirmed sugarcane as an excellent plant option. The need to find alternative sources of carbon other than oil to produce bioplastics and biofuels also offers Australia's sugarcane industry new and potentially profitable business opportunities.

These biomaterials can be produced either in sugarcane as alternative products or co-products with sucrose (through R&D from the Biofactory subprogram) or by downstream processing of pre-existing compounds harvested from sugarcane (from the Biorefinery subprogram). To develop these new materials, the industry will rely on this CRC's underlying research knowledge, scientific platforms, enabling technologies and strategic alliances.

Production of High-Value Materials

The aim of the Biofactory subprogram was to establish sugarcane as the preferred host for plant-based production of specific high-value materials and ensure Australia leads the field with associated IP-protected technologies. It brought together different technologies for producing high-value alternative sugars and biopolymers in

sugarcane. Its strategic research helped to inform selection or engineering of high-value sugarcane varieties. High-value varieties potentially produce higher yields or improved compositions of materials that assist downstream biological or chemical conversions into specific value-added products.

Sugarcane's high photosynthetic efficiency and ability to generate high quantities of stored sucrose, cellulosic fibres, lignins and surface waxes make it an ideal vehicle for generating these downstream products. Its capacity to store soluble products and the composition of its lignins and epicuticular waxes also make it an ideal industrial crop for synthesising several types of high-value products. Because it is vegetatively propagated, sugarcane's genetic make-up does not change, making bio-product development extremely reliable. Opportunities also exist for the co-generation of electricity needed to extract and process from bagasse (the fibre or biomass left over after liquid sugar has been extracted from the cane).

There is a growing market for plant-derived food additives and nutraceuticals. Some high-value waxes and flavonoids are already biosynthesised by sugarcane and are likely to be produced by the industry soon. The opportunity exists for the industry to establish as a leader in supplying this growing market if economic co-production levels and separation

processes can be established.

The CRC's approach to this challenge has combined:

- application of gene technologies to understand the biosynthesis of these materials, enhance production levels and shift production to economically preferred forms; and
- development of growing, harvesting and extraction technologies for optimal recovery of these materials, as well as sucrose.

Taking advantage of renewables

While production of high-value materials in plant biofactories is a strategy for the future, production of materials from available renewable resources by chemical and/or biological conversion is well established. Ethanol, organic acids (lactic acid, citric acid), amino acids (lysine, glutamate, phenylalanine), sugar alcohols (e.g. sorbitol) and many fine chemicals (e.g. enzymes, penicillins) are examples of products derived from renewable resources.

The Biorefinery subprogram sought to show the potential of taking greater advantage of sugarcane streams for large-scale production of such materials and identify similar new high-value products for the industry.

Large-scale fermentation facilities are usually sited next to sugarcane mills. This offers

Program Two

the advantages of an efficient supply of biomass from the sugar milling stream and electricity co-generated from bagasse, as well as use of dunder - the dregs of cane juice fermentation - to fertilise surrounding cane fields. The chemical and process engineering and molecular biotechnology expertise within this CRC provided substantial scope to generate IP related to increased extraction efficiencies and conversion to high-value downstream products.

In partnership with the Australian sugarcane industry, this CRC helped to develop the base for producing value-added materials from sugarcane-derived feedstocks or harvesting,

milling and refining by-products and wastes. Examples include alcohols, biofuels, fibre products, biopolymers, biosurfactants, industrial enzymes and renewable biomaterials to replace industrial petrochemicals used in plastics manufacture.

PROJECT SUMMARIES

Testing sucrose accumulation

Understanding how sucrose accumulates in sugarcane will underpin future strategies for increasing sucrose or other high-value products in sugarcane. The aim of this research was to

develop improved transformation methods especially for smut-resistant varieties, identify and test key genes in the sucrose accumulation process by manipulation in transgenic sugarcane, test promoters believed to target expression most strongly to the storage parenchyma and complete the PhD training of three PhD students. This project was focused on intellectual property (IP) capture and the provision of a suite of tools to improve the production of transgenic sugarcane plants.

Following are the significant achievements for 2009/10.

1. Further testing a sugarcane promoter in transgenic

2009/10 Highlights

- > The CRC SIIB filled a new patent in its GI Wise™ portfolio. The patent focuses on a glycemic index lowering extract from bagasse. A clinical trial in humans demonstrates that the extract can reduce postprandial glycemia and insulinemia of high GI foods.
- > CRC participants, Metabolix, BSES and The University of Queensland, were successful in an ARC Linkage grant application, which secures a further five years of funding to continue the development of CRC IP on PHA bioplastics production in sugarcane.
- > A new promoter for enriched expression in storage parenchyma was validated.
- > Efficient and sustained down-regulation using of genes involved in sucrose accumulation was demonstrated.
- > Field trials confirmed that three different transgenic technologies can generate commercially useful sugarcane lines.
- > Methods for determining sugar properties were developed and used to produce detailed information on the structure-property relationship of sugars.

... this CRC helped to develop the base for producing value-added materials from sugarcane-derived feedstocks or harvesting.

sugarcane which has been demonstrated to drive tissue-enriched transcript expression (exemplified by a reporter gene) in the storage parenchyma of maturing stem in order to enhance its action. One hundred and seventy-three reporter gene-positive plants were confirmed during the year with approximately three hundred more plants to be tested at the very end of the project. This will be followed with the development of assays for reporter gene expression.

2. Sustained down-regulation was demonstrated in transgenic sugarcane of transcripts corresponding to five genes selected for manipulation in transgenic sugarcane to determine their effect on sucrose accumulation.

PHA production in sugarcane

Polyhydroxyalkanoates (PHAs) is a family of natural polymers that can replace plastic produced from non-renewable resources. The commercial partner on this project, Metabolix, is already establishing large-scale microbial production from corn starch. Production of PHAs in sugarcane has the potential to significantly reduce cost of production.

This project focused on determining where and how to best produce PHA in sugarcane.

Steady progress was made in 2009/10 to increase PHB production in sugarcane. Our previous results suggested an opportunity existed to increase PHB production by expressing the plastic in some cellular structures (plastids) in a large area of the leaf (constituting some 50% of the leaf biomass) where expression had previously been absent. Through an understanding of the chemical pathways involved in that area of the leaf, and the controlling influences at each step in the pathway, we have been able to apply treatments which make more of the chemical precursors available in the leaf for PHB production. Applying these treatments to six-month-old glasshouse-grown plants has resulted in the predicted increased levels of PHB, not only in the targeted areas but in other tissues as well.

Additional modifications were made to the lipid synthesis pathway of the plants in an effort to further increase PHB synthesis. As a result PHB has now been expressed in a range of cellular areas not previously used to store the generated PHB.

As a result of our new understanding and experience in the metabolic pathways of sugarcane we have been able to extend a genome scale model of *Arabidopsis thaliana* (AraGEN) to represent C4 plant species by the addition of reactions and transported typically found in C4 plants. This new model

(C4GEN) is now being validated for its ability to synthesize different biomass components and to predict the metabolic pathway activity. C4GEN was also able to predict the classical C4 photosynthesis and its major effect in various plant structures.

Field evaluation of GM sugarcane

This project aims to assess the field performance of GM sugarcane produced by three different transgenic technologies: agrobacterium-mediated transformation, conventional plasmid-based and the new minimal DNA-based biolistic methods.

During 2009/10 accurate yield and CCS data (Stage 3 trial) was obtained for nearly 40 transgenic lines. Analysis of results suggests that growth and cane yield reduction was observed in plants produced by both Agrobacterium-mediated and biolistic transformation methods, relative to wild-type (no transformation or tissue culture) controls. Importantly, growth and yield of 10 to 15 per cent of transgenic lines, depending on the transformation method used, were comparable to wild type suggesting that both techniques could be used to recover agronomically suitable material. Interestingly, a large proportion of the negative impact on growth and cane yield found in transgenic lines was also present in tissue cultured plants.

Program Two (cont'd)

Importantly, transgene expression analysis over time and crop class suggests that it remains stable over successive crops and increases with plant age.

Bioactive natural products from sugarcane

This project delivered its objective to identify bioactives from sugarcane waste stream that have commercial potential in terms of pharmaceutical, functional food and nutraceutical applications. During 2009/10, the project focused on refining IP generated by the project and the overall concept was trademarked GIWise™.

To date, four compounds have been identified (two of which are novel) that demonstrate potent inhibitory activity against enzymes involved in the initial digestion of complex carbohydrates. This IP was covered in a provisional patent application and may be of interest to pharmaceutical companies for the treatment of diabetes.

Another IP that was evolved during the year is the development of a process for the large-scale production of an active extract from sugar cane leaf and/or bagasse that shows comparable enzyme inhibitory activity with a commercial drug acarbose. In a clinical trial conducted using a high carbohydrate food i.e. instant mashed potato, it was demonstrated that the extract

is able to reduce glycaemia and insulinemia. Thus, the extract can modify the glycaemic index (GI) of foods, which is important in the management of diabetes. This extract can find applications in the functional food and/or nutraceuticals arena.

Alternative sugars

This project aimed to identify technologies to produce alternative sugars for food applications or as industrial chemicals.

During the past year, researchers cloned and expressed enzymes with the potential to modify sucrose and create new products. The applications of these novel sugars in the food or chemical industries will depend on their physical and sensory properties. Sweeteners ideally need to have similar taste and properties to sucrose but with improved health benefits. CRC researchers have developed laboratory methods to test industry-relevant properties of sugars, including sweetness, crystallisation, digestibility and cariogenicity (ability to form dental caries). The results highlight structure–function relationships among sugars.

Potential IP was identified in two novel sugars which were shown to have equivalent sweetness to glucose. The decision was made not to proceed with protection of this IP because the sweetness was less than that of sucrose and because no economic method of production could be identified.

Other IP delivered is in the form of knowledge of candidate sugars and assay techniques.



This extract can find applications
in the functional food and/or
nutraceuticals arena.



Program Three

EDUCATION



EDUCATION

Overview

The third program in the CRC portfolio is Education, designed to enhance the biotechnology and business skills of promising young researchers and increase industry and public awareness of biotechnology opportunities.

The program was administered mainly through The University of Queensland and involved regular interaction with CRC researchers and students, and industry representatives. These interactions allowed us to share our research achievements appropriately with CRC participants and the public.

The first and most important program aim was to educate and train undergraduate and postgraduate students in skills

that will add product value to agricultural export industries. Our activities were tailored to produce CRC SIIB graduates who are familiar with relevant technologies and industry and community perspectives and who understand new and emerging biotechnology industry priorities.

The second aim was to increase industry awareness of available biotechnology opportunities and allied business and technical skills.

We tackled this through the CRC's partners in government, industry and academia, by integrating teaching and training at undergraduate, postgraduate and in-service levels in agricultural biotechnology. The educative focus was on building our intellectual capital so new products could be generated

from sugarcane beyond the CRC's life. Our community communication was the key to developing informed public understanding of beneficial new technologies and a knowledge-based future for the industry.

1) Tertiary education and industry interactions

Education and training of students, industry and the community are vital CRC SIIB activities. Through our close links to sugarcane research groups such as BSES Limited, and through a strong communication program, CRC SIIB education has strived to keep industry and community members informed about the latest sugarcane research and its industry applications.



Program Three (cont'd)

2009/10 Highlights

- > As at 30 April 2010, ten students had completed their PhD degrees, two students had completed their Masters degrees, and 14 students had completed their Honours degrees. A total of 41 postgraduate students have worked with the CRC SIIB since 2003.
- > Student training recognition by some industry organisations that have employed our highly-skilled graduates with recently completed qualifications.
- > CRC students' co-authored 33 publications from 1 July 2009 to 30 June 2010, including 10 refereed journal articles.
- > The 'Negotiating for Authorship' workshop, developed in 2007 around CRC's trade mark authororder®, was successfully run at The University of Queensland, Southern Cross University, the University of Western Sydney, the University Putra Malaysia, and at the CRC Association conference's Research Managers' workshop in 2009 and 2010.
- > The 'Authorship News' newsletter, 'Avoid authorship pitfalls with authororder®' Facebook group, 'authororder' Twitter page, and 'I survived the CRC SIIB' Facebook group were launched in 2009 and 2010.
- > Nomination for Cooperative Research Centre Association Award for Excellence in Innovation in Education and Training for the authorship management training program.
- > Suzanne Morris and the authorship management training program were a finalist in UniQuest's Trailblazer 2010 Competition.
- > The sixth CRC SIIB Research Symposium was held in Brisbane.
- > Education staff participated in and gave seminars at major sugarcane industry events to raise awareness of the CRC SIIB's research and biotechnology in general. One paper on the CRC's postgraduate education program and another paper on the CRC's industry biotechnology workshops that were run in 2008/09 were presented at the 2010 ASSCT conference in Bundaberg.
- > CRC SIIB and the ARC Centre of Excellence in Integrative Legume Research (CILR) teamed in July 2009 to run the 'Saving the planet with biotechnology' workshop in UQ's Faculty of Science Experience Science Week. About 30 high school students from South-East QLD participated in the workshop to learn about various aspects of plant biotechnology related to the CRC and CILR.
- > CRC SIIB and the Public Awareness section of the Federal Department of Innovation, Industry, Science and Research staff ran a booth entitled 'Powering Australia's future' at the '2009 Brisbane Ekka'.
- > Education staff participated in the ARC Linkage project 'Research and Innovation Leaders for Industry'.

2) Evaluating school education

The long-term aim of this project was to work with, educate and train students in schools and the community about sugarcane biotechnology.

The project achieved its objectives, including the development and implementation of educational strategies and resources for teaching middle and senior phase students about complex issues and concepts associated with the processes and products of biotechnology and increasing students' awareness of biotechnology.

Some of the resources were modified for use by Primary teachers (following professional learning workshops to support their understanding of biotechnology) in several Queensland schools.

Teaching and learning resources include a digital resource toolkit, experimental inquiry activities and teaching support strategies for instruction on biomaterials as well as a web page of resources and an inquiry teaching module with instructional support strategies around the socio-scientific issue 'Should Australia grow GM crops?'.

Our research indicated that our teaching strategies and educational materials promoted student knowledge of biotechnology and scientific literacy. The opportunity for Australian science teachers to learn more about the project was extended through workshops in 2009 where teachers learnt about our project outcomes and associated teaching materials. A range of teacher workshop materials were devised and used to support these professional workshops.



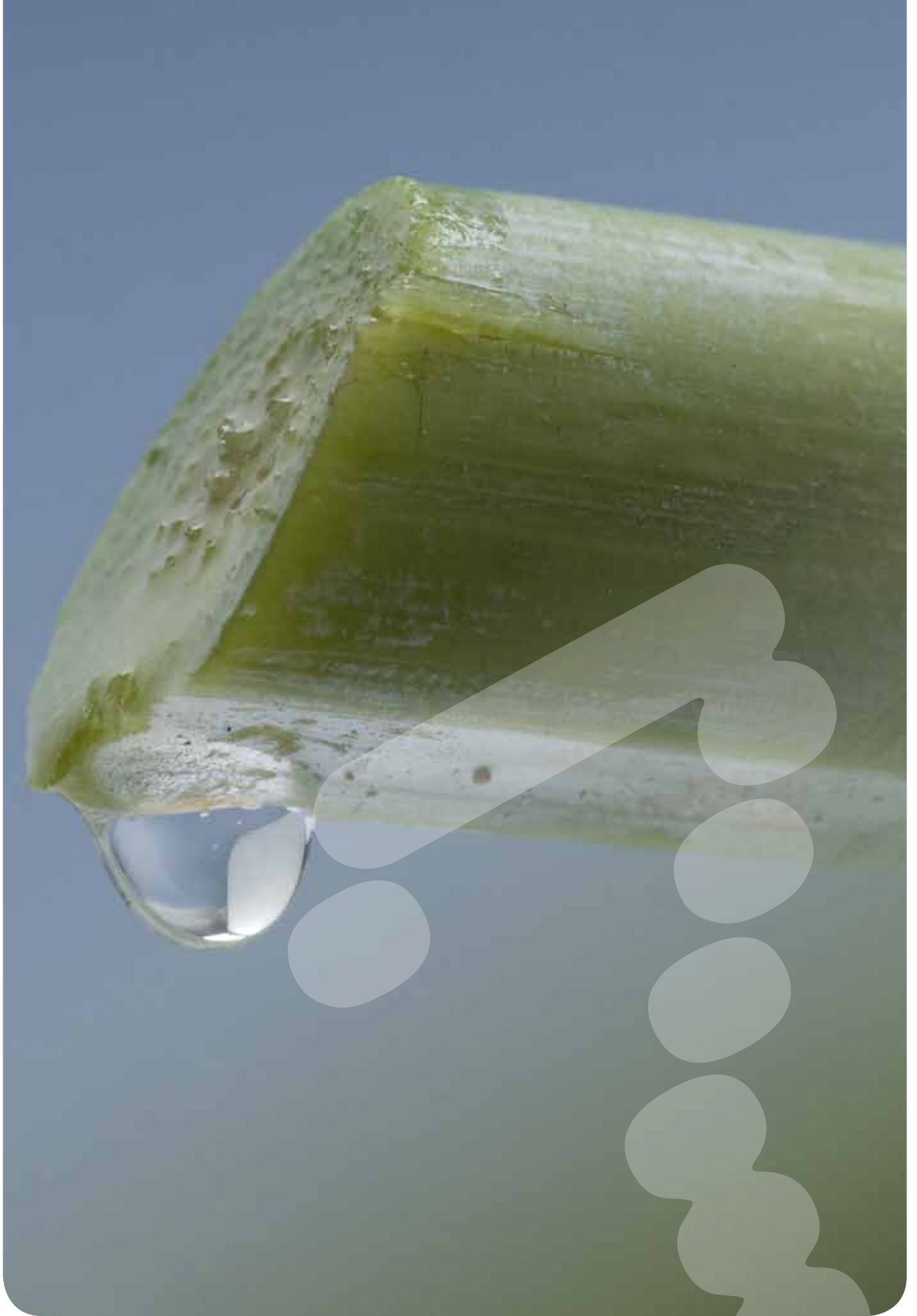
Student Table

Student Name	Project title	RHD program	Supervisors	CRC project	Stipend	Start Year	University	Graduate destination
Graeme Scheuber	Carbonic anhydrase in sugarcane, isozymes, relative activity and association with sucrose accumulation	Hons	Burnell (JCU)	1a1		2004	JCU	Office of the Government Statistician, Queensland
Lorelene Bowler	Optimisation of in vitro <i>Paenibacillus popilliae</i> sporulation	Hons	Smith, Geijskes (QUT) Nutt (BSES)"	1b2		2005	QUT	Research Assistant; BSES
Fabian Tan	Improved production process for <i>Metarhizium anisopliae</i>	Hons	Reid (UQ) Mordocco (BSES)	1b2		2004	UQ	Research Assistant; Institute of Molecular and Cell Biology, Singapore
Ekaterina Nowak	Understand the biology and ecology of sugarcane to manage the safe release of GM cultivars	Masters	Bonnett (CSIRO)	1b5		2006	Griffith	PhD; UQ
Rosanna Powell	Understanding the reproductive biology and ecology of sugarcane to manage the safe release of genetically modified cultivars	Hons	Schmidt (UQ) Bonnett (CSIRO)	1b5		2007	UQ	Research Assistant; BSES
Kerry Vinall	Root traits in the context of nitrogen acquisition in sugarcane	PhD	Schmidt (UQ) Lakshmanan (BSES) Watt (CSIRO)	1b6	APA/CRC top-up	2006	UQ	Research Assistant; UQ
Alexander Whan	Achieving a better understanding of nitrogen efficiency in sugarcane through molecular markers	PhD	Schmidt (UQ) Lakshmanan (BSES) Aitken (CSIRO)	1b6	CRC	2004	UQ	Postdoctoral Research, CSIRO Canberra
Heather Vikstrom	Root traits of sugarcane (<i>Saccharum</i> ssp.) in context of nitrogen use efficiency	Hons	Schmidt, Robinson (UQ)	1b6		2009	UQ	Research Assistant; BSES
Richard Brackin	Organic nitrogen uptake in sugarcane	Hons	Schmidt (UQ)	1b6		2007	UQ	Research Assistant; UQ
Cassandra Clayton	Identification and development of novel bacterial biocontrol agents	PhD	Smith, Timms, Geijskes (QUT) Nutt, Allsopp (BSES)	1b7	CRC	2005	QUT	Research Officer, bioMérieux Australia Pty. Ltd
Geoffrey Dun	Role of monocot branching genes in sugarcane	PhD	Beveridge (UQ) Hermann, Lakshmanan (BSES)	1b8	CRC	2004	UQ	
Chuong Ngo	Molecular analysis of suckering and tillering in sugarcane	PhD	Beveridge (UQ) Hermann, Lakshmanan (BSES)	1b8	SRDC	2002	UQ	Research Assistant; BSES

Student Name	Project title	RHD program	Supervisors	CRC project	Stipend	Start Year	University	Graduate destination
Karno	Physiology of bud outgrowth in sugarcane	PhD	Beveridge (UQ) Bonnett (CSIRO) Lakshmanan (BSES)	1b8	AusAid	2003	UQ	Lecturer; Diponegoro University, Indonesia
Ouzi Amouyal	Sucrose phosphate synthase characterisation and function	PhD	Bundock, Henry (SCU)	1c7	CRC	2004	SCU	Technical Office, SCU
Suzelle Geijskes	Development of a high level expression system for the production of bioplastics in sugarcane	PhD	Dale, Collet (QUT) Lakshmanan (BSES)	2a11	CRC	2004	QUT	Research Assistant; QUT
Lygia Romanach	Understanding knowledge and attitudes to genetic engineering among sugar industry stakeholders based on qualitative and quantitative analysis	PhD	Wegener, Morris (UQ), Grice	2a6	CRC	2005	UQ	
Karl Pioch	Sugar transporters in the tonoplast	PhD	Critchley (UQ) Grof, Rae (CSIRO)	2a7	UQPRS/ CRC top-up	2006	UQ	Postdoctoral Research, University of Cologne
Hayati Iskandar	Expression and function of genes associated with sucrose storage and osmotic stress tolerance in sugarcane stems	PhD	Maclean (UQ) Bonnett, Manners (CSIRO)	2a7	AusAid	2004	UQ	Researcher; Indonesian Biotechnology Research Unit for Estate Crops, Bogor, Indonesia
Mark Jackson	Identification and functional characterisation of genes encoding vacuole-targeted proteins in sugarcane parenchyma	PhD	Maclean (UQ) Rae, Manners, Bonnett (CSIRO)	2a7	CRC	2004	UQ	Postdoctoral Research Fellow; UQ
Kimberly Tilbrook	Production of PHB in the peroxisomes of plants	PhD	Schenk, Brumbley (UQ)	2a8	APA/CRC top-up	2006	UQ	
Kylie O'Keefe	Towards understanding gene silencing of the Cavendish Banana Streak Virus promoter in sugarcane	Hons	Brumbley (UQ)	2a8		2008	QUT	
Lisa Meiers	Towards understanding gene silencing of the Cavendish Banana Streak Virus promoter in sugarcane	Hons	Brumbley (UQ)	2a8		2008	QUT	
Louise Ryan	Towards understanding gene silencing of the Cavendish Banana Streak Virus promoter in sugarcane	Hons	Brumbley (UQ)	2a8		2008	QUT	
Robert Chang	Early screening of transgenic sugarcane	Hons	Lovell, Brumbley (UQ)	2a8		2007	UQ	PhD UQ

Student Table (cont'd)

Student Name	Project title	RHD program	Supervisors	CRC project	Stipend	Start Year	University	Graduate destination
Glenn Hassall	Identification of regulatory elements for efficient foreign gene expression in sugarcane plastids	PhD	Collet, Bateson, Geijskes (QUT) Lakshmanan (BSES)	2a9	CRC	2004	QUT	
Noriko Abiko	Expression of transgenes in sugarcane plastids	Hons	Geijskes (QUT)	2a9		2008	QUT	Research Assistant; QUT
Adam Smith	Alternate vectors for plastid transformation	Hons	Geijskes (QUT)	2a9		2007	QUT	
Victor Arias Espana	Clarification of cane juice for polylactic acid production	PhD	Hardin, Do (UQ)	2b10	CRC	2004	UQ	Postdoctoral Research Fellow; UQ
Wendy Chen	Effect of gene dose on hyaluronic acid metabolism	PhD	Nielsen, Hung (UQ)	2b11	CRC	2005	UQ	Postdoctoral Research Fellow; NTU, Singapore
Linda Le	Biotransformation of sucrose using sucrose phosphorylase	Hons	Duggleby (UQ)	2b2		2004	UQ	
Dionne Payn	Phytochemistry of sugarcane	PhD	Leach, Deseo (SCU)	2b3	CRC	2005	SCU	
Rory Taylor	Pharmacology of sugarcane	PhD	Morris, Leach (SCU)	2b3	CRC	2004	SCU	
Colin Archer	Metabolic engineering of E. coli for improved sucrose utilization	PhD	Nielsen, Vickers (UQ)	2b4	CRC	2007	UQ	
Yalun Arifin	Metabolic engineering of sucrose metabolizing E.coli	PhD	Nielsen, Kromer, Vickers (UQ)	2b4	AusAid	2006	UQ	
Jenny Vo	Metabolic engineering of E. coli for organic acids production	Hons	Nielsen (UQ)	2b4		2007	UQ	PhD; UQ
Brian O'Neill	Sugarcane as a biofactory: production of alternative polysaccharides	PhD	Nielsen, Brumbley (UQ)	2b8	CRC	2002	UQ	
Marguerite Renouf	Evaluating the environmental implications of product diversification in the Australian sugar industry	PhD	Pagan, Wegener (UQ)	2b9	APA/CRC top-up	2002	UQ	Lecturer, UQ
Richard Cooper	Doing science artfully: Science as a 3D verb	PhD	Nichols, Renshaw (UQ)	3a4	Griffith	2007	UQ	Researcher, Griffith University
Kalani Eggington	An investigation of teacher-scientist collaborations in a biotechnology context	PhD	Wright, Nichols, Geelan (UQ)	3a4	UQPRS/ CRC top-up	2007	UQ	
Harold Kanasa	Evaluating education and understanding of sugar cane biotechnologies in Queensland middle years classrooms and the community	PhD	Nichols, Geelan, Wright (UQ)	3a4	UQPRS/ CRC top-up	2007	UQ	Research Assistant, Griffith University
Annette Hilton	Digital technologies and multimodal communication in the chemistry classroom	PhD	Nichols, Gitsaki (UQ)	3a4	Ed QLD	2006	UQ	Australian Catholic University, Melbourne



Program Four

**COMMERCIALISATION
AND UTILISATION**

COMMERCIALISATION AND UTILISATION STRATEGIES AND ACTIVITIES

The CRC has continued its strong focus on developing and commercialising Intellectual Property (“IP”). Significant progress has been made towards successfully achieving the milestones detailed in the Commonwealth Agreement.¹

Commercialisation development

Barrecote™

During the year there was significant global interest in our product Barrecote™. Barrecote™ is a waterproofing product for paper and cardboard. Unlike conventional wax waterproofing, Barrecote™ treated paper and cardboard is fully recyclable.

As a result of this interest, our commercialisation staff have been engaged in commercialisation discussions with industry leaders in paper and cardboard manufacturing. Barrecote™ is now being tested in the laboratories of several Australian and overseas companies, and a leading Australian company will soon commence a production machine test application of Barrecote™.

¹ Milestone 4.1.7 – Commercial development underway. Milestone 4.1.8 – CRC technologies delivered to end users.

GI Wise™

GI Wise™ is extracted from sugarcane waste (“bagasse”), and is significantly more effective at controlling blood sugar levels than current, widely used medications on the market. Recent CRC-run human trials of GI Wise™ produced promising results.

During the year, our CRC engaged in GI Wise™ commercialisation discussions with overseas-based pharmaceutical and nutraceutical companies and with CRC SIIB participant - Queen NutraPharm Pty Ltd. Queen have experience in manufacturing specialised food additives and access to national and international retail outlets and food markets.

End Users

Genome Profiling Service

Diversity Array Technology Pty Ltd (DARts) released a commercially-available, cost-effective, whole sugarcane genome profiling service. This service makes use of CRC SIIB technology to populate the genome with thousands of genetic markers.

As a result of our licensing arrangements with DARts, our CRC was paid royalties for the use of its technology. Under the terms of the licensing agreement, we have arranged for DARts to provide the Australian sugarcane industry with reduced rates for accessing the genome profiling service.

Authorship®

CRC SIIB Education compiled a training package aimed at helping researchers and students determine the correct order of authors as listed in a publication. During the year, our CRC held authorship order workshops for research organisations and universities. These workshops proved successful. A monthly authorship newsletter has since been launched.

Our commercialisation staff are currently in talks with a third party to continue these workshops beyond the closure of the CRC SIIB.

Australian Sugarcane Mapping and Breeding Program

Improved sugarcane varieties are fundamental for the future performance of the Australian sugarcane industry. Through our research, the CRC SIIB identified genetic markers in sugarcane that relate to commercial traits such as improved disease resistance, higher sugar content, or increased sugarcane yields.

Genetic markers have had limited use in sugarcane breeding programs, despite their successful application to breeding programs involving other crop species. We have developed cost-effective ways to apply these genetic markers to sugarcane breeding programs. The use of DNA markers in sugarcane breeding programs will produce new improved

Program Four (cont'd)

sugarcane varieties in time-efficient and cost-effective ways.

The IP in the genetic markers and its data relating to the application of genetic markers in sugarcane breeding programs have been assigned to CSIRO and BSES Ltd.

Metabolix Inc.

Our CRC has a research and technology commercialisation agreement with Metabolix Inc. (Metabolix), a CRC participant and US-based company that produces biodegradable plastics. Under the agreement Metabolix has been granted the option to commercialise the outcomes of a CRC SIIB project that aimed to produce biodegradable plastics using sugarcane. Metabolix has indicated that upon completion of the project, it will proceed with the commercialisation option.

In our negotiations with Metabolix, we have ensured that the Australian sugarcane industry receives the maximum benefit from the commercialisation agreement. Under the agreement the Australian sugarcane industry has been granted rights to all new product development and commercialisation opportunities utilising the project IP. Further, if the Australian industry proceeds with the product development, it will do so with preferential royalty rates. It is anticipated these benefits will enhance the Australian sugar industry's global position.

Spin-off company

Sacron Innovations Pty Ltd (Sacron Innovations) was created by our CRC with the backing and support of its participants, who are shareholders in the company. At present Sacron Innovations has two purposes:

firstly to assist in the winding up of the CRC SIIB, and secondly, to commercialise CRC IP. After the closure of our CRC and the completion of wind up activities, Sacron Innovations will focus on commercialising CRC IP assigned to the company.

Patents

- > Enzymes and Methods for Degrading Chlorinated S-triazines, 19 December 2007, Sugar Industry Innovation Pty Ltd.
- > Polyhydroxyalkanoate Production in Plants, 11 July 2007, Sugar Industry Innovation Pty Ltd.
- > Compounds Affecting Glycemic Index, 16 April 2010, Sugar Industry Innovation Pty Ltd.
- > Glycemic Index Lowering Extract and Method of Extraction, 28 April 2010, Sugar Industry Innovation Pty Ltd.
- > A Method for Treating a Paper Product, 11 July 2008, Sugar Industry Innovation Pty Ltd.
- > A Method for Coating a Paper Product, 11 July 2008, Sugar Industry Innovation Pty Ltd.
- > Production of Hyaluronic Acid, which is a merger of the following two applications:
 - > Production of Hyaluronic Acid (1), 31 August 2007, Sugar Industry Innovation Pty Ltd and the University of Queensland.
 - > Production of Hyaluronic Acid (2), 14 May 2008, Sugar Industry Innovation Pty Ltd and the University of Queensland.

Trade Marks

- > Barrecote™ Australian Trade Mark Application, Sugar Industry Innovation Pty Ltd.
- > GI-Wise™ Australian Trade Mark Application, Sugar Industry Innovation Pty Ltd.
- > Authorder®, Australian Registered Trade Mark, Sugar Industry Innovation Pty Ltd.

Intellectual Property Management

Our CRC strongly adheres to the National Principles of IP Management through its provision of guidelines and support to researchers on recognising the potential value of new discoveries, and how to best protect or exploit them. We have a clear policy on the ownership and rights associated with IP generated from CRC-funded research and this has been communicated to all stakeholders involved in CRC SIIB research and research programs.

During our seven years of research and development, our CRC has endeavoured to raise awareness of IP and IP related issues with our researchers and students. These efforts have allowed us to engage in honest and frank discussions with our researchers and students regarding research progress, and possible outcomes. This focus on IP has enabled us to efficiently identify, secure and commercialise or otherwise exploit IP.

With wind up of the CRC SIIB on 30 June, there has been much focus on the IP generated by our CRC, and how it could best

be utilised to return maximum benefit to Australia. As a result of discussions with CRC Participants, we released several pieces of IP into the public domain where it can best benefit the Australian sugarcane industry. At the time this report was drafted, efforts were underway to commercialise IP that would not enter the public domain, so that the Australian sugarcane industry is provided with alternative revenue streams.

No new IP was developed and sold, transferred or licensed for commercialisation during the reporting period.



COMMUNICATION STRATEGY

The CRC SIIB communication program has kept our staff and the Australian sugarcane industry in touch with our work; importantly the program has stimulated interest here and overseas in groundbreaking Australian science outcomes.

Strategy objectives

Our second communication strategy, developed in 2007-08, provided a framework to guide and support all CRC SIIB research and development activities.

Our program objectives have been to:

- provide credible advice and information;
- create awareness and understanding of the scope, direction and outcomes of the CRC SIIB's research through two-way communication;
- maintain and gain additional support for, and involvement in, CRC SIIB; and
- implement a cohesive approach to CRC SIIB communication.

During the final year of our CRC, the communication program helped to market the potential of bioproducts and value-added sugarcane to all stakeholders.

A new area on commercial products was developed and added to our web site.

Additionally, reference was made throughout the year to our research outcomes and their application in the commercial world through a series of articles and web site updates sent to our stakeholders, the broader sugarcane industry, scientists, commercial bodies, the general public and other members of our audience where appropriate. Communication played a key role in extending the commercial outcomes of our CRC.

Once again, Communication released regular 'public' information on our CRC's activities. Monthly media releases were distributed through media monitors to selected databases. Media follow-ups across the board were positive, including particular interest from ABC news networks, University magazines and various national and international news websites, and the national CRC newsletter. Our stories on Weediness in Sugarcane research, and ongoing publicity on our outcomes during our final year, attracted sustained media interest. Additionally, regular feature stories on a wide range of our projects were submitted to specialty publications such as the BSES Bulletin and Australian Sugarcane.

Early in the year Communication worked closely with the Genome Mapping Project to educate the CRC's audiences of the significance of genome research to the Australian sugarcane industry. In August 2009 we

helped publicise the Genome Conference in Port Douglas and developed a specialised media kit for national and international research and media groups.

Internally, our key achievements, significant internal events and staff career development options were published every six to eight weeks and distributed to staff, students and key stakeholders as a web-based newsletter.

CRC Communication worked extensively on special events during the later half of 2009 and first half of 2010. Our National Famers Federation Conference display (July 09) focused on our contributions to the future development of bioproducts based on sugarcane. Throughout July and August 2009 we produced a 'commercial products' handout and matching banner/poster for an international biotechnology conference held in August in Montreal. We provided support for several education events and school presentations, including a 'how to make bioplastics' handout and a similar handout on 'how to conduct a simple fermentation experiment'.

Further to this, we put together the display for the CRC's section at August 2009 Exhibition held in Brisbane. This exhibit focused on Qld Science and the green energy potential of a lot of the work now underway in Qld. About 4000 leaflets, including information on our projects and the potential of biotechnology to develop environmentally 'smart' products such as bioplastics

2009/10 Highlights

- > Production and release of the 2009>10 Annual Report and Highlights.
- > Strong uptake of CRC SIIB media releases, including regular coverage on ABC radio news, national and international web coverage of several commercial stories, good regional media coverage throughout Qld and northern NSW, university magazines and websites, specialty science and innovation magazines and international websites.
- > Media interest in a release on the Genome Mapping Project (sent out in August 2009) and the Sugarcane Weediness project (several releases and feature stories distributed throughout the year).
- > Fortnightly updates and reviews of our main website including news updates and science highlights and revamped photographs to reflect the commercial status of our CRC.
- > Regular e-newsletter sent to internal CRC SIIB, industry and commercial contacts.
- > Ten feature stories published in major sugar industry and research magazines.
- > Graphics and media support for an International Genome Mapping Conference held in Port Douglas in August 2009.
- > Development of two Award submissions for the Annual CRC Conference held in Darwin.
- > Revision of CRC SIIB web site to ensure usability of the site as it remains live through to June 2014
- > Staging of a bioproducts display for various education events, the 2009 Royal National Show (RNA) held in Brisbane in early August, the 2009 World Bio Congress held in Montreal in July 2009, a new display on CRC SIIB outcomes for the final CRC SIIB Research Symposium in May 2010 and the 2010 Australian Society of Sugarcane Technologists Conference.

and recyclable cardboard, were distributed to students of all ages and the general public.

Communication was behind our CRC's involvement in the 2010 ASSCT as a principal sponsor. The potential of Biotechnology research and it's applications to the sugarcane industry was the focus of the 2010 ASSCT. Our display, Outcomes CD, handouts and powerpoint presentations presented delegates (including Australian and international sugarcane researchers, growers and business people) with the latest information on and benefits to arise from our work. The display was well visited and received many positive comments/queries. Excellent coverage of ASSCT was achieved, including

television broadcasts across the state quoting Dr Peter Twine. Towards the end of our CRC Communication provided support for our final Research Symposium through media and web site publicity, development of powerpoints, and information folders.

Early in 2010 Communication staff worked on two submissions to the national CRCA research and education awards. Our submissions involved significant research, editing and final layout to produce two professional documents for the prestigious annual CRC event.

Ongoing development and maintenance of an internal photo library resulted in exciting new imagery to support communication activities.

Bioproduct and novel sugarcane photos have been used throughout the year on our website, published material and in the many displays we took part in during the year. Some of the other communication services provided during the year included the production of a range of images on request for media, presentations and various websites, preparation and printing of CRC SIIB stationery, development of artwork for CRC SIIB promotional items, and continued review of interest in our website via Google Analytics.

The communication strategy is available at:
www.crcsugar.com

Program Four (cont'd)

End User Involvement and CRC Impact on End Users

Our CRC continued to actively engage with, and promote, its end user alliances', which provide benefits not only to our CRC, but also to the sugarcane industry. Through these affiliations, we assisted sugarcane producers by disseminating knowledge on improved farming practices and improving sugarcane varieties. We also encouraged the development of alternative revenue streams for the industry through partnerships that promoted the research and development of alternative sugarcane uses.

End-user name	Relationship with CRC	Type of activity and end-user location	Nature/scale of benefits to end-user	Actual or expected benefit to end-user
DARts Pty Ltd	Licensee	Development and application, Canberra, Australia	Service provider	\$100k + per annum
Metabolix Inc	Participant	Bioplastics company, Boston USA	Technology development	Currently undeterminable
KAIST	Research partner	University, Korea	Research and development	Currently undeterminable
Sugarcane millers and producers	Industry	Cane growing, Queensland and northern New South Wales	Dissemination of knowledge and improved sugarcane varieties	\$10 million + per annum
Dow AgroSciences LLC	Former Participant and Licensee	Agricultural company, Indianapolis USA	Research and development	Currently undeterminable
CSIRO/BSES sugarcane breeding program	Participants	Sugarcane Industry Breeding Program, Queensland	Genetic markers for improved sugarcane varieties	\$1million + per annum



Exit Statement

The Cooperative Research Centre for Innovation through Biotechnology wound up its operations on 30 June 2010.

As part of the reporting requirements to the Department of Innovation, Industry, Science and Research CRC SIIB CEO, Dr Peter Twine, submitted an Exit Report.

The Report details CRC SIIB outcomes, the legacy left to the Australian sugarcane industry, and any challenges faced during the seven years of research and development.

Aspects of this report including our seven year highlights can be found on www.crcsugar.com.





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