Molecular Plant Breeding CRC

Annual Report 05-06

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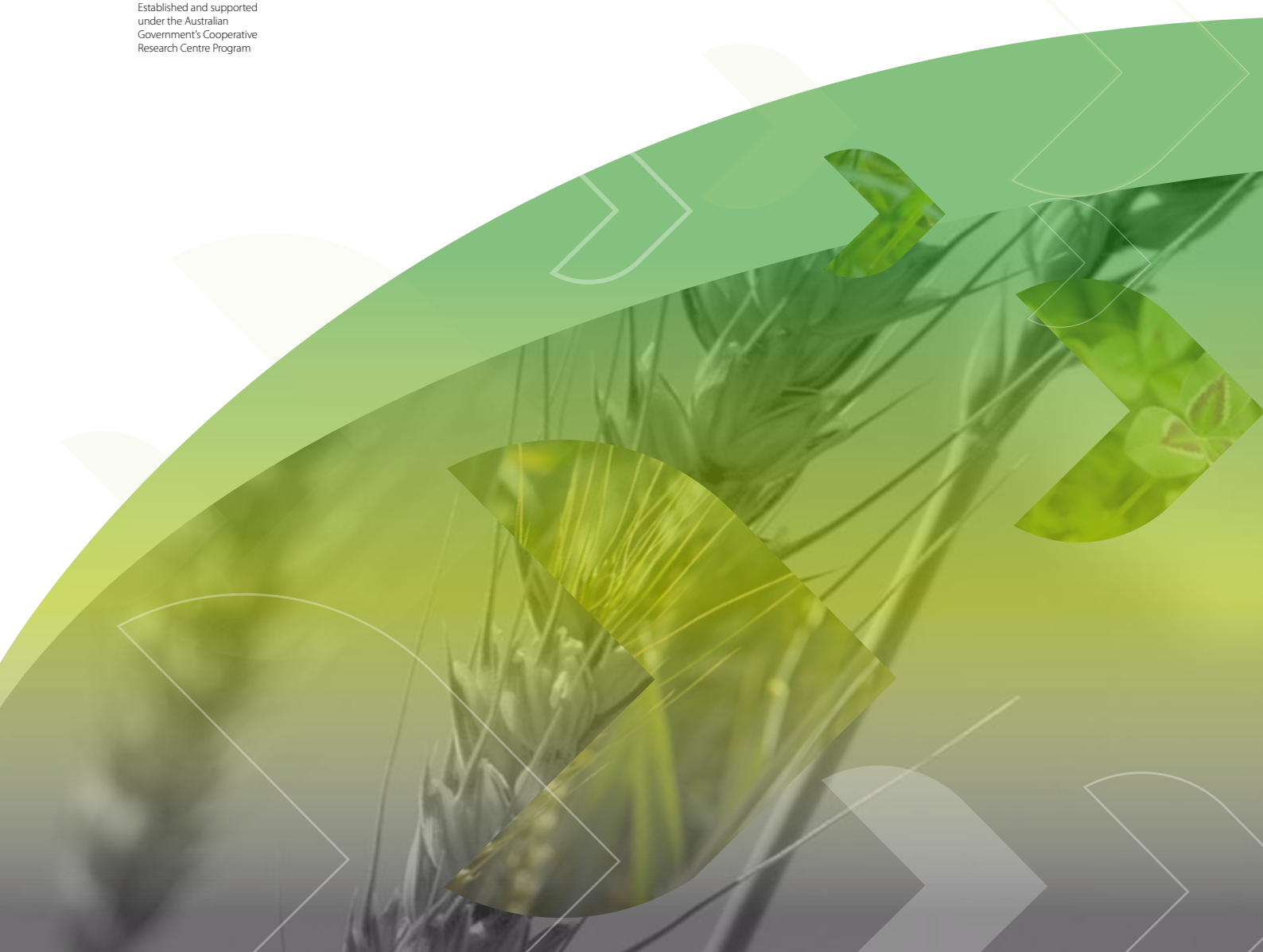

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ASSOCIATED ORGANISATIONS

Core participants

Department of Primary Industries, Victoria (DPI Vic)

The University of Adelaide

South Australian Research and Development Institute (SARDI)

Department of Agriculture and Food, Western Australia (DAFWA)

Murdoch University

International Maize and Wheat Improvement Centre, Mexico (CIMMYT)

Supporting participants

Southern Cross University

International Centre for Agricultural Research in the Dry Areas, Syria

Australian Grain Technologies (AGT)

ABB Grain Ltd

BASF Plant Science

Grains Research and Development Corporation (GRDC)

Dairy Australia (DA)

South Australian Grains Industry Trust

Meat and Livestock Australia (MLA)

Geoffrey Gardiner Dairy Foundation (GGDF)

Joint venture partner

PGG Wrightson Limited

CHAIRMAN'S REPORT

As Chairman of the Molecular Plant Breeding CRC I understand the broad relevance of our research portfolio to industry, but as a primary producer, I can truly appreciate the potential impact that our technologies can have. With another dry year just past and another drought predicted for next year, MPBCRC's drought tolerance research is more relevant than ever. Australian farmers, unlike our European and American competitors, do not have the benefit of substantial growers' subsidies to cushion us against the hard times. The scientific advances made within MPBCRC will be crucial if we are to remain competitive in the world.

This year MPBCRC underwent some significant changes to its leadership and structure. In late 2005 Dr Bryan Whan announced his retirement as CEO. Bryan's experience in plant breeding and research management has made a lasting contribution to MPB. Under his eight years of leadership the CRC has grown into an internationally recognised research centre with an enviable reputation for delivering high quality science. He goes with our profound thanks and deepest gratitude for helping to make the CRC the success it is today.

In February 2006 the Board announced the appointment of a new CEO, Dr Glenn Tong. Glenn has a strong background in biotechnology commercialisation and in the formation and management of biotechnology joint ventures. He has a successful track record in securing important commercial transactions that will be crucial in delivering the CRC's technologies to the end user as well as capturing some value for the CRC and its stakeholders.

The Board believes that he has the necessary skills and experience to take the CRC forward into the next stage of its development: the commercialisation of our research.

In June 2006 Cheryl McCaffery, our Commercial Director, advised that she would not be seeking renewal of her employment contract and would be relocating to Singapore for family reasons. Cheryl has made significant contributions to MPB's intellectual property management and commercialisation activities and we will all miss her very much. The CRC wishes Cheryl all the best in her future endeavours.

To remain successful, MPBCRC needs to constantly monitor the prevailing environment in which we operate and adjust our strategy accordingly. To this end, I have asked our new CEO to implement a comprehensive review of the CRC's Research Portfolio and return to the Board with recommendations on how best to capitalise on our scientific achievements in the remainder of the present funding round. This internal Research Portfolio Review will take place in July 2006, to be followed by DEST's Third Year Review in October 2006. These two reviews will prepare us for some key decisions that MPBCRC has to make in order to capture the most value for our pasture and cereal industries over the next four years. This may also help position the CRC for a potential further round of funding.

Dr Tony Gregson FTSE

CEO'S REPORT

This is my first report as CEO of MPBCRC. As a relative newcomer to the CRC, it is immediately clear to me just what great scientific and commercial potential resides in MPB's research portfolio.

MPBCRC finalised two major commercial partnerships this financial year. In November 2005, we signed the final agreements for Gramina Pty Ltd, a $36 million joint venture with PGG Wrightson Ltd (New Zealand). As part of this joint venture, PGG Wrightson secured the largest grant to date ($3 million) from New Zealand Trade and Enterprise's Australia New Zealand Biotechnology Partnering Fund and MPB secured $5 million worth of supplementary funding from DEST. Together our two organisations can now move forward in the development of the world's first transgenic pasture grass varieties with enhanced nutritive quality and reduced pollen allergens. The joint venture was officially launched in February 2006 by the Victorian Minister for Innovation, the Honourable John Brumby, and with the final documents now executed, the product development phase has begun in earnest.

In May 2006, BASF Plant Science confirmed its intention to expand its involvement in the joint research and development program with MPBCRC. The $28 million program will develop high yielding wheat lines that are more resistant to drought and fungal disease. BASF has identified MPBCRC as the research facility of choice for wheat transformation globally, and this is a major vote of confidence in the research capability of the CRC and a significant boost to this research project.

MPBCRC's commercialisation activities are underpinned by world-class research and there have been a number of key research milestones achieved this year. Our wheat quality improvement work in Program 3 at the Waite Campus was given a substantial boost from the South Australian Premier's Science and Research Fund. The contribution of over $600,000 to support our work in this area over the next three years should significantly accelerate progress.

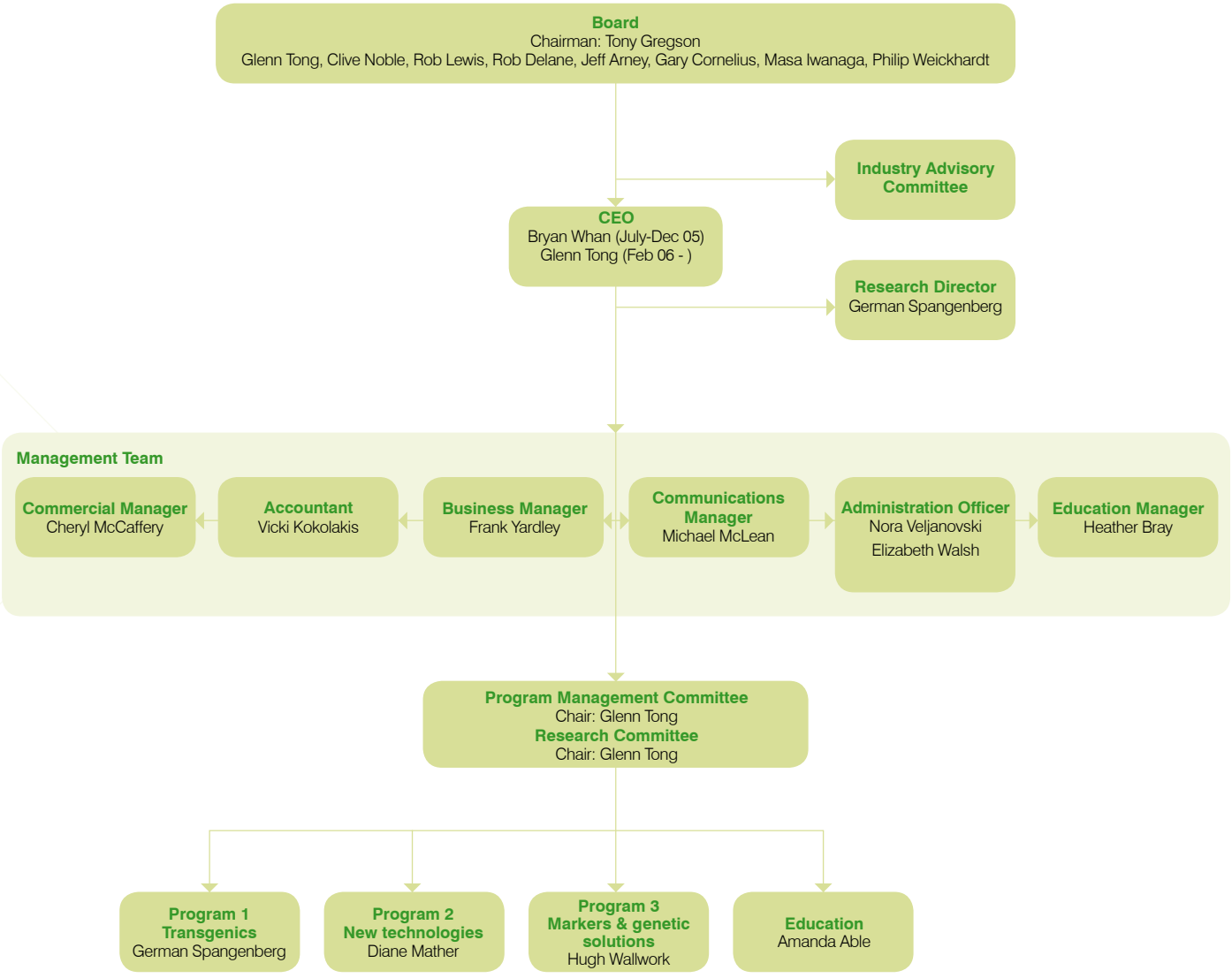
MPBCRC's project on molecular marker technologies for pasture plants, which is co-funded by Geoffrey Gardiner Dairy Foundation (GGDF), Dairy Australia (DA) and Meat & Livestock Australia Ltd (MLA), was critically reviewed by four independent expert reviewers in 2006. The science and commercialisation strategies stemming from this project received a high level of praise, and in fact, some reviewers commented that this research group was the best in the world in its field.

Our Education Program team continues to do us proud and was this year officially recognised for its successes with an award. *Get into Genes*, our secondary school education workshop run in partnership with the Australian Centre for Plant Functional Genomics (ACPFG), was awarded for Excellence in Innovation in Education and Training by the Cooperative Research Centre Association. *Get into Genes* is an interactive biotechnology education program that highlights the importance of gene technology in crop improvement. Over 3,000 students have taken part since its inception in 2004, and with the recent expansion of the program to Victoria, we hope to reach many more students.

My first few months on the job have been like a whirlwind, but when the dust settles, it is clear that in the four years ahead there are many opportunities for creating and capturing substantial value for MPBCRC and its stakeholders and partners. I look forward to working closely with everyone at the CRC to realise the considerable potential that exists.

Dr Glenn Tong

GOVERNANCE, STRUCTURE & MANAGEMENT



THE BOARD

Dr Tony Gregson

Chairman (Independent)

Tony Gregson is a grain grower from Victoria's Wimmera region. He has an extensive science and corporate research management background. He has PhD and DSc degrees from the University of Melbourne and has held academic positions at the University of New England, the University of North Carolina at Chapel Hill and at Oxford.

Tony is a Fellow of the Royal Australian Chemical Institute and the Australian Academy of Technological Sciences and Engineering. He is Chairman of the International Plant Genetic Resources Institute based in Rome, a member of the CGIAR Alliance Board and the CGIAR Genetic Resources Policy Committee. He is also Deputy Chairman of Plant Health Australia, Chairman of the University of Ballarat Water In Drylands Collaborative Research Program, a member of the Crawford Fund Board of Governors and Chairman of the Victorian Crawford Fund Committee. He was an inaugural Board member of CSIRO and the GRDC, and a Board member of the Rural Finance Corporation of Victoria, the Australian Nuclear Science and Technology Organisation and of CIMMYT in Mexico.

Dr Glenn Tong

Chief Executive Officer (Independent)

Glenn Tong graduated from the University of Melbourne with a Bachelor of Science (Hon) and PhD (specialising in the chemical synthesis of modified DNA). Since transitioning from research to biotechnology commercialisation in the mid 90's, Glenn has established a successful track record in the negotiation and execution of commercial transactions, including collaborative R&D agreements, joint ventures, in and out licensing agreements and capital raisings. Previously, Glenn was Managing Director and CEO of Pacific Oligos Pty Ltd (subsequently Genset Pacific Pty Ltd, Proligo Australia Pty Ltd and now part of the Sigma group), Managing Director (Commercial) of AgGenomics Pty Ltd and Director and Principal of BiotechSmarts Consulting. Glenn is a member of the AusBiotech Ag Bio Advisory Group and the Australian Institute for Company Directors.

Dr Rob Lewis

Rob Lewis is the Executive Director of the South Australian Research and Development Institute (SARDI). His career has covered marine research, research management, government policy, intellectual property management and commercialisation. He holds a BSc (Hon) from Adelaide University and a DSc (*honoris causa*) from Flinders University for his contribution to the marine sciences and industries. He is a Fellow of the Australian Academy of Technological Sciences and Engineering and is Chair of the SA Division. Rob currently sits on several Boards including the SA Premier's Science and Research Council, Australian Genome Research Facility Pty Ltd, AGT Pty Ltd, Crawford Fund and the South Australian Advisory Board of Agriculture. Significant former positions include South Australian Director of Fisheries, Chair Council Australian Maritime College, Board Australian Fisheries Management Authority, Chair Commonwealth Fisheries Research Advisory Committee, Chair Australian Southern Bluefin Tuna Management Advisory Committee and the South Australian Primary Industries Research and Development Board.

Dr Masa Iwanaga

Masa Iwanaga holds a MS degree in wheat cytogenetics from Kyoto University, Japan and a PhD in Plant Breeding and Plant Genetics from the University of Wisconsin, USA. He has more than two decades of research and management experience in international development. His association with the research centres supported by the CGIAR began with the International Potato Centre (CIP) in Peru, where he was a cytogeneticist. He then worked for CIAT, Colombia, IPGRI, Italy and JIRCASA, Japan. He is currently the Director General of CIMMYT.

Mr Rob Delane

Rob Delane is Deputy Director General (Biosecurity and Research) with the Department of Agriculture and Food Western Australia (DAFWA). He has extensive experience and skills in agricultural policy, strategic planning, research strategy, resource management, regulation and service delivery. He has held key positions in research management and biosecurity policy, regulation and program delivery. He is a Graduate of the Australian Institute of Company Directors. He is a director of Plant Health Australia, member of the national Quarantine and Exports Advisory Council and a commissioner of the Western Australian Agricultural Produce Commission.

Mr Philip Weickhardt

(Independent)

Philip Weickhardt has been a Commissioner with the Productivity Commission since 2004, having previously served as an Associate Commissioner. Prior to this, Philip was CEO of Orica (previously ICI Australia), a Director of ICI Australia and Chairman of Incitec and ICI NZ. This experience with ICI Australia and Orica gave him extensive experience relevant to leading a large international group with a significant R&D program and in the international commercialisation of new technology. Philip is an Adjunct Professor at the Mt Eliza Business School and is Chairman of two not-for-profit organisations: the Earthwatch Institute and Pilotlight Australia. Philip also sits on an Advisory Board for Monash Energy (part of the Anglo American Group) and chairs a CEO Roundtable for CEDA. He has a Master of Science from Melbourne University and has completed the Advanced Management Programme at Harvard Business School.

Mr Gary Cornelius

(Independent)

Gary Cornelius is a Senior Adviser and Director of Leadenhall VRG, corporate advisers, specialising in the valuation of companies, businesses and intellectual property. He is a Fellow of the Finance and Treasury Association and the Institute of Company Directors. His background includes over thirty years in consulting, banking, finance and international trade in Australia and overseas. He undertook a part-time secondment to the South Australian Department of Premier and Cabinet as an adviser on economic and financial issues to the Micro-Economic Reform Unit from 1994 to 1998 and regularly consults to Governments at a high level. He is also a director of a number of companies including Flinders Bioremediation Pty Ltd and Technology Investment Corporation Pty Ltd.

Dr Clive Noble

Clive Noble is the Executive Director of PIRVic, the Research and Development Division within the Victorian Department of Primary Industries. Clive has overall managerial and leadership responsibility for the resources and activities of PIRVic.

He is also a Director of Agriculture Victoria Services Pty Ltd, the commercial arm of PIRVic. Clive has extensive experience in rural Victoria and in science leadership, having been a Regional Manager for DPI and the Institute Director of the Tatura/Kyabram/Cobram based Institute. He has had extensive roles with industry and the community through representing government on catchment management boards, industry associations and commonwealth committees. Clive's research background is associated with plant breeding and plant physiology, particularly associated with irrigation management.

Mr Jeff Arney

(Independent)

Jeff Arney is a commercial grain and seed producer with broad experience in industry policy development and R&D, including experience in varietal testing and evaluation. Jeff has a mixed farming property near Bordertown, South Australia, where he grows wheat, barley, pulses, oilseeds, irrigated lucerne and other seed crops. He is highly regarded across the state as a progressive farmer, and through his involvement with many state and national industry organisations has an extensive knowledge of the field crops industries.

Jeff has held numerous leadership roles in the grains industry. He has served as president of the Grains Council of Australia and chairman of SA Farmers' Federation Grains Council. Jeff is currently a panel member of GRDC for the Southern Region (SA, Victoria and southern NSW) and is a serving member of the Plant Breeders Rights Advisory Committee.

CONTEXT & MAJOR DEVELOPMENTS

Industry context

MPBCRC remains relevant to the needs of the grains and pasture industries by targeting agronomic outcomes which are vital to ongoing viability. The Australian grains industry does not have financial assistance in the form of subsidies or restitution payments, like the European Union or USA, which buffer grain growers from adversity in terms of crop losses or production problems. The pasture industries, including the dairy, beef and wool industries, are at a turning point where molecular breeding can bring about considerable benefits in the form of significantly improved varieties. This places increased importance on scientific advances designed to address the challenges specific to Australian producers.

MPBCRC's research is targeted at delivering varieties which are able to withstand stresses in many forms. For example, MPBCRC is pivotal in conducting research on tolerance to drought, the single most threatening environmental stress in this nation. One of the technologies that holds great promise in addressing this problem is genetic modification, and MPBCRC continues to demonstrate its capability in this area through recent developments such as partnerships with BASF Plant Science (developing genetically modified drought-tolerant and fungal resistant wheat) and PGG Wrightson through Gramina Pty. Ltd. (developing genetically modified grasses with improved digestibility, nutrititive quality and hypoallergenicity). Other tolerances that remain important to industry are frost, heat and the significant threat of leaf and stem rusts which are very expensive to control with fungicides and can result in significant losses.

The MPBCRC partner organisations maintain collaborative links with key breeding programs and have worked closely together sharing progress at the Annual Research Meeting and at other times during the year. The wider industry has also contributed to the research directions of the CRC and is consulted both via the Industry Advisory Committee and informally through industry gatherings and meetings.

Reviews

In 2006 MPBCRC staff invested a significant amount of time preparing for two reviews of its activities.

To evaluate the quality and industry relevance of MPBCRC's research projects, a review of the entire research portfolio was conducted. A review committee comprising senior MPB staff and two external reviewers considered all current projects. Findings of the review committee will be reported to the Board in August 2006 and will guide strategic direction for MPBCRC's remaining four years.

Preparations for the Department of Education Science and Training (DEST) Third Year Review commenced in early 2005 and a sub-committee of the Board was appointed as the Steering Committee. An independent panel has been appointed to conduct the review. Plans to conduct an independent industry survey are under way and Review Panel site visits are expected to be conducted in October 2006.

Staff appointments

In December 2005 Bryan Whan stepped down as CEO of MPBCRC. Commercial Director Cheryl McCaffery acted as interim CEO from late December 2005 to February 2006, at which time Glenn Tong was appointed as CEO.

COMMERCIALISATION

Technology transfer: commercialisation approaches

Commercial Director: Cheryl McCaffery

To facilitate uptake of molecular marker technologies, MPBCRC seeks alliances with end users whose strategic focus and principles accord with our own. This involves forging close relationships with the breeding programs to facilitate both rapid dissemination and uptake of the latest research.

Because MPBCRC is an extension of the first-round CRC for Molecular Plant Breeding, it already has a well established reputation for excellence in this field. MPBCRC marker technologies are in demand and new markers are disseminated routinely for use by breeding programs under limited technology licences. These outputs are freely disseminated to the local breeders.

For selected technologies, however, the preferred approach is to obtain protection using legal instruments such as patents and plant breeders' rights (PBR). Such approaches are particularly applicable to biotechnologies that are based on the application of recombinant DNA techniques. Because of the high investment required to bring these kinds of products to market, the competitive advantage afforded by IP protection is seen as almost mandatory. Patents and PBR provide property rights, and these rights are tradable commercial assets. By giving the owner control over how the technology is used, the owner can realise the value of the technology through the sale or granting of licenses.

MPBCRC uses both the above approaches to encourage and facilitate uptake and application of the outcomes from its research programs.

Major activities during 2005-06

MPBCRC has four major collaborative research and licensing agreements with the Germany-based company BASF Plant Science (BPS) to develop transgenic wheats that exhibit fungal resistance and drought tolerance. Progress in these projects has been excellent and all four agreements have been extended for a further four years.

The agreements with BPS also foreshadowed the establishment of a robust wheat transformation system, and it is pleasing to report that this is now well under way. A patent application has been filed and MPBCRC and BPS are now in active discussions regarding the establishment of an entity to perform wheat transformations.

In relation to the non-transgenic cereals effort, MPBCRC's research programs continue to generate marker technologies and methodologies for use in cereal breeding programs. This occurs largely through MPB participant breeding organisations AGT and DAFWA. Further efforts are being made to determine the most appropriate commercialisation arrangement for these activities. This is occurring in an industry context that has seen considerable change over the last 12-18 months.

Molecular marker development for marker implementation in pasture plant improvement is achieved by a somewhat different mechanism. The CRC's activities in this area are strongly supported by representatives of the industry participants: DA, GGDF and MLA. As there are only a few forage seed companies, and as assessment of the markers in an end user's breeding material is critical, deployment of new technologies in this industry involves forming strategic alliances with specific participants. An agreement has recently been reached with one industry participant to establish a trial implementation program.

On the transgenic pasture side, Gramina Pty Ltd finalised the Product Licence, Sales and Marketing Agreement with Wrightson Seeds Limited (a wholly owned subsidiary of PGG Wrightson Limited), providing the licensee with the rights to commercialise products emanating from the activities of the joint venture. Progress in this development and commercialisation project is on track and regular strategic meetings of the parties ensure that the focus on developing industry-relevant products is maintained.

The delivery of grasses with enhanced nutrition and greater digestibility will increase livestock productivity. Grasses with enhanced nutritional value, drought resistance and improved seasonal growth patterns represent a key mechanism for raising the productivity of Australia's livestock industries.

PATENT APPLICATIONS AND GRANTED PATENTS OWNED BY MPBCRC

Technology Area	Application Title	Countries where protection is being sought: Application number	Status
Simple Sequence Repeats (SSR)	Molecular markers in ryegrass and fescues	Australia: 72468/00	Granted and sealed
		New Zealand: 509193	Accepted
Lignin genes	Modification of lignin biosynthesis	New Zealand: 523033 New Zealand: 532000 New Zealand: 532001	Granted and sealed
		New Zealand: 542667 Australia: 2001 265670 Europe: 01942874.7 USA: 10/311450	Applications in various stages of prosecution
Fructan genes	Fructosyl transferase homologues from ryegrass and fescue species	New Zealand: 523538	Granted and sealed
		Australia: 2001 265676 Europe: 01942880.4 USA: 10/311193	Applications in various stages of prosecution
Disease resistance	Modification of plant resistance to diseases and/or pests	New Zealand: 523538 Australia: 2001 276169	Granted and sealed
		USA: 10/333091	Accepted
		Europe: 01953687.8	In prosecution
Lifecycle genes	Manipulation of plant life-cycles and/or growth phases	New Zealand: 525585 Australia: 2002 213672	Granted and sealed
		Europe: 01981971.3 USA: 10/416316	Applications in various stages of prosecution
Gene promoters	1. Use of bi-functional alpha amylase-subtilisin inhibitor promoter to direct expression in pericarp of plants	Australia 2003: 271420	National Phase entered April 2005
Gene promoters	2. Pollen-specific promoter	Australia: 2004 249788 USA: 10/561283 New Zealand: 544217 Europe: 04737025.9	National Phase entered April 2005
Multiplex-ready marker technology	Method of amplifying nucleic acid	International Phase PCT/ AU2006/00318	Complete Specification filed: Now in unpublished PCT stage
Wheat transformation	Method for wheat transformation using *Agrobacterium*	Australia 2006 900826 USA: 60/757,994	Provisional applications filed

IP management

New Intellectual Property

One new patent filing was made during the past 12 months. The invention is a novel method for the genetic transformation of plants of the Graminaceae family, which includes pasture grasses and cereals such as wheat. The technology provides the CRC with a means of transforming wheat in a way that should avoid the need to in-license other third party technology. The method is presently being more thoroughly demonstrated, prior to filing the complete patent application in January of 2007. It is also being developed with a view to being deployed in the provision of transformation services to other Australian and overseas-based organisations.

Intellectual Property sold, transferred or licensed

Following the establishment of Gramina, the technologies and transgenic grass seed products which that company will develop have now been licensed to Wrightson Seeds Ltd for multiplication, marketing, sales and distribution in Australasia and other target overseas markets.

End user involvement and CRC's impact on end users

Delivery of outcomes from MPBCRC's research and development activities depends critically on the close involvement of end user organisations. This is partly due to the nature of our R&D: development and implementation of new technologies for improving crop breeding must of necessity involve organisations in crop breeding.

The breeders at AGT and DAFWA work closely with the CRC so that as the CRC homes in on a marker for a desirable trait, the breeders can incorporate that marker into their breeding programs as soon as the information becomes available. The breeders are now routinely using markers generated by the CRC.

In the case of pasture grasses, close collaboration is essential as all the projects utilise the end users' proprietary germplasm.

RESEARCH COLLABORATION

MPBCRC's research programs are structured to focus on outputs – tangible products and services for commercialisation and delivery to end users. Only by keeping abreast of industry need will the CRC ensure both a return on Australia's investment in research and the ongoing competitiveness of Australian crop and pasture industries.

Collaboration is a key factor in the successful delivery of MPBCRC's target outputs. This year, MPBCRC maintained 27 international collaborative arrangements (with 18 organisations) and 25 national collaborations.

A range of collaborative frameworks and partnerships have been established for effective technology development and commercialisation of MPBCRC research outputs. One highlight in the transgenic pastures area has been the progress Gramina Pty Ltd has made in the commercialisation of GM grasses with enhanced herbage quality and reduced pollen allergenicity.

MPBCRC research on molecular markers in pasture grasses benefits from close collaboration with the three stakeholder groups that co-fund the research, and from interactions with national and international research groups in plant and animal genetics. Direct collaborations with the pasture crop breeding industry are now planned, starting with a pilot project with Agriseeds New Zealand to obtain 'proof-of-concept' for the application of candidate-gene single-nucleotide polymorphism (SNP) haplotype data in pasture grass breeding.

MPBCRC research on molecular technologies for wheat and barley involves extensive collaboration nationally and internationally. Multiplex-ready marker technology is now deployed in several labs across Australia, often in support of collaborative projects. Within Australia, there are collaborations among MPBCRC participants (eg to deploy multiplex-ready marker technology), with ACPFG (eg for map-based cloning of a barley quantitative trait locus (QTL)), within the Australian Winter Cereal Molecular Marker Program and with wheat and barley breeding programs (eg for protein profiling and solid-phase marker development and for whole-genome selection). International collaborations include genetic analysis projects conducted with researchers in the UK, North America and China and a leadership role in an international consortium for wheat genome sequencing.

Estimation of gene effects and prediction of cross outcomes relies upon close collaboration with cereal breeding programs and involves MPB researchers in Victoria and South Australia, as well as a linkage with the Value-Added Wheat CRC and Sydney University. MPB bioinformatics initiatives involve interdisciplinary links between computer scientists and biologists and significant interactions between MPB participants in Western Australia and South Australia and between MPB participants and ACPFG. In 2005-06 researchers from three MPB participant organisations were the major contributors to a new GRDC map curation project.

In developing the Premier's Science and Research Fund project, MPBCRC has drawn in the expertise and in-kind contribution of Daryl Mares (University of Adelaide) including his work on the genetics of yellow alkaline noodles and also of Tony Rathjen, durum breeder in the University of Adelaide. This has enabled the coordination of resources and provided the critical mass to secure additional funding ($647,900) from the SA Department of Further Education, Employment, Science and Technology. This project also involves the input and support of the wheat breeding entity AGT and Lauke Flour Mills.

MPBCRC has drawn together the barley pathogen work of Klaus Oldach (SARDI), Felicity Keiper (SARDI) and Amanda Able (University of Adelaide) to work towards a coordinated program of tackling basic research into barley pathogens and their interaction with the host. This will hopefully be realised in future through joint projects covering aspects of the host, pathogen and their interactions

PROGRAM 1 Transgenics: Developing gene systems and delivering transgenic technologies

PROGRAM LEADER: Prof German Spangenberg

Objectives

Program 1 will increase the rate of genetic gain in cereal and pasture plant improvement through the development of novel transformation methodologies and gene systems and their delivery in transgenic breeding. Transformation events with improved tolerances to environmental stresses such as drought, improved disease resistances and new quality attributes will be developed in wheat, perennial ryegrass and white clover and delivered to breeding programs.

Background

The primary focus of Program 1 is to develop and deploy genetic modification techniques to enhance cereal and pasture molecular breeding. MPB is working to develop new and improved methods for the production of GM, or 'transgenic', wheat, perennial ryegrass and white clover. Candidate genes for important traits such as drought tolerance and fungal disease resistance are being identified and assessed in GM wheat. Genes involved in key metabolic pathways and developmental processes are being identified and evaluated in GM perennial ryegrass and white clover to develop pastures with enhanced herbage quality and human health outcomes.

Novel tools for transgenesis

The production of GM plants is a powerful tool for the analysis of plant gene function as well as for the development of novel transformation events for incorporation in transgenic breeding programs. Projects within Program 1 aim to develop novel tools for transgenic breeding in cereals and pastures. These include the development of a toolbox of promoters (regulatory gene sequences) required to target the expression of transgenes (transferred genes) to specific organs and tissues and to regulate transgene expression in a developmental- and environmental-controlled manner.

A set of promoters for organ-specific, tissue-specific and inducible expression has been identified, isolated and evaluated in transgenic wheat plants. In addition, following microarray-based expression profiling in wheat leading to the identification of novel candidate genes with a diversity of expression patterns, novel wheat promoter sequences were isolated for *in planta* evaluation.

A major requirement for the production of 'market-ready' transformation events is to reduce the complexity of transgene integration patterns. The aim is to produce transformation events which contain a single copy of the transgene and are free of selectable markers. Genetic transformation using the soil bacterium *Agrobacterium tumefaciens* has been demonstrated to result in a higher frequency of single/low copy transgene insertions. Research undertaken within Program 1 will develop a robust and efficient *Agrobacterium*-mediated transformation system for wheat. A baseline protocol has already been established and the process is currently undergoing further refinement.

Novel genes for transgenesis

Program 1 focuses on developing novel gene systems for transgenic breeding in cereals, primarily wheat, and pastures. The program also involves isolating and characterising novel genes of significant potential benefit to breeding programs, such as genes controlling chromosome pairing and recombination, or genes involved in the regulation of resistance to plant pathogens.

Research is being conducted to identify and characterise genes located within and outside the Ph (pairing homoeologous) region of bread wheat that control the chromosome pairing and recombination processes. Isolation of these genes could be of significant benefit to breeding programs as tools for accelerated alien gene introgression. Based on comprehensive microarray-based transcriptome analysis, candidate genes involved in meiotic processes have been identified in wheat. They are now undergoing functional analysis through the production of transgenic barley or wheat plants with modulated expression of these genes.

Other research has led to the identification of novel candidate genes for drought tolerance and non-host fungal disease resistance. With drought tolerance currently a national research priority, this is a crucial area of research. A set of these identified and isolated genes has already been transferred to wheat to assess their performance in conferring tolerance to abiotic and biotic stresses. Additional candidate genes for drought tolerance and non-host fungal disease resistance have been identified for detailed functional analysis in GM wheat. This project has made great progress, prompting our commercial partner, BPS, to increase its investment and significantly expand the project scope.

In the move towards more sustainable production systems in the 21st century, increased productivity and profitability of pasture-based dairy systems is required. These increases are being pursued by focusing molecular plant breeding efforts on increasing nutritive value and biomass production of forage grasses (such as perennial ryegrass), improving quality for enhanced animal welfare and increasing abiotic stress tolerance and nutrient efficiency of forage legumes (such as white clover).

Consequently, MPBCRC has already identified and isolated novel genes involved in lignin biosynthesis and fructan metabolism for their deployment in molecular breeding of GM pasture grasses with enhanced nutritive value. Furthermore, genes involved in the biosynthesis of organic acids and proanthocyanidins in white clover have been isolated and characterised for their deployment in molecular breeding of GM pasture legumes with aluminium tolerance and bloat safety.

Perennial ryegrass and tall fescue frequently contain endophytic fungi (*Neotyphodium lolii* in ryegrass and *N. coenophialum* in fescue) which form symbiotic relationships with the host plant. The presence of the endophyte has been shown to improve seedling vigour, persistence and drought tolerance in marginal environments as well as provide protection against some insect pests. However, endophyte-infected grasses may be toxic to livestock because the fungus produces a range of chemicals, some of which have a high degree of biological activity against mammalian systems.

A systems biology approach to study the endophyte/grass symbiotic association has been enabled through development of the world's first genomic resources in *Neotyphodium* endophytes, including a comprehensive collection of expressed sequence tags and unigene microarrays as well as other underpinning tools and methodologies for genome, transcriptome and metabolome analyses. It is expected that knowledge arising from this research will lead to enhanced endophyte-grass combinations for improved pasture quality, safety and production.

Novel transformation events for breeding

Building on novel tools and novel genes for transgenesis arising from existing research activities, market-ready transformation events will be generated in wheat, perennial ryegrass, tall fescue and white clover.

These novel transformation events will incorporate transgenic technologies following a sensible choice of targets for molecular breeding.

After thorough analyses under contained laboratory and glasshouse conditions, selected transformation events are evaluated in small-scale planned field releases.

Following successful completion of the world's first field assessment of novel transformation events in ryegrass with a down-regulation of the main pollen allergen, a development program for the generation of hypo-allergenic ryegrass to reduce incidence of hay fever and seasonal allergic asthma can be considered.

Transformation events in perennial ryegrass for modified lignin and fructan biosynthesis were produced as a first step towards the development of high-energy ryegrass.

Transformation events in white clover for modified organic acid biosynthesis were produced as a first step towards the development of aluminium tolerant, nutrient efficient clover.

Featured project report

1.1.11b Deployment of transgenic technologies in white clover

Leader: Prof German Spangenberg

White clover is an important component of temperate pastures worldwide. Clover, as a legume, fixes nitrogen in the soil and provides dairy cattle with a high quality protein source. However, clover is sensitive to aluminium toxicity in acidic soils, which are common in Australia. Its high protein content can also contribute to bloating in ruminant animals, with implications for animal welfare and farm budgets. This project aims to improve the aluminium tolerance of white clover by increasing the production and secretion of organic acids. The project also aims to improve the bloat-safety of white clover by increasing the level of condensed tannins in leaves.

A large-scale gene discovery program undertaken in white clover led to the generation of 50,000 expressed sequence tags. The resulting DNA sequences were compared to genes in public databases, enabling the identification and functional categorisation of approximately 15,000 unique clover genes. This collection of clover genes has been analysed by computational methods in order to identify candidate genes that could be involved in metabolism, development or the responses of plants to stress.

Candidate genes related to organic acid and condensed tannin production have been identified in white clover on the basis of their similarity to characterised genes from other plants. A number of candidates have been cloned and fully sequenced. The candidate genes involved in proanthocyanidin biosynthesis identified in white clover include chalcone synthase, anthocyanidin reductase and leucoanthocyanidin reductase. The candidate genes involved in organic acid biosynthesis identified in white clover include citrate synthase, nodule-enhanced malate dehydrogenase and phosphoenolpyruvate carboxylase. Full length cDNAs corresponding to the candidate genes have been isolated, sequenced and corresponding transformation vectors for their over-expression in transgenic white clover plants have been produced. Transgenic white clover plants for the over-expression of candidate genes individually and in a combined manner have been produced and are being analysed. Transgenic strategies that aim to increase the production of condensed tannins in leaves and the production and release of organic acids from roots, using the candidate genes, will form the basis for the development of white clover germplasm and cultivars with enhanced bloat-safety and aluminium tolerance

Researchers: Dr Stephen Panter, Dr Aidyn Mouradov, Marcel Labandera (student), Amanda Winkworth, Jason Simmons.

PROGRAM 2 New Molecular Technologies

PROGRAM LEADER: Prof Diane Mather

Objectives

MPB's New Molecular Technologies Program aims to increase the rate of genetic gain in cereal and pasture improvement through novel molecular technologies, strategies for genomic analysis and software tools for research and plant breeding. The Program includes three main areas of research activity:

- Molecular markers for pasture crops, involving the discovery and deployment of molecular markers for perennial ryegrass and white clover
- Molecular technologies for wheat and barley, involving development and delivery of novel DNA and protein marker technologies and novel strategies for marker-assisted cereal research and breeding
- Molecular plant breeding information, involving bioinformatics systems and analysis, data curation and management, data analysis, prediction and simulation.

Molecular markers for pasture crops

MPB's molecular marker strategy for pasture crops involves discovery of SNP markers within candidate genes and deployment of these markers for crop improvement. MPB has developed SNP markers for over 150 genes in perennial ryegrass and for about 130 genes in white clover. These markers have been used in genetic mapping. Traits associated with herbage yield, herbage quality and tolerance to abiotic stresses have been assessed in populations of both species. The genetic control of these traits has been studied, with QTLs detected in specific genomic regions, including one region in perennial ryegrass that affects herbage digestibility and contains three candidate genes for lignin biosynthesis. Those genes are now being targeted in a proof-of-concept experiment to associate variation among within-gene SNP haplotype structure with variation in herbage quality traits.

Industry stakeholders (DA, GGDF, MLA) co-fund MPB's pasture crops molecular markers research and contribute to project planning through participation in technical and commercialisation committees. Future plans involve further basic research to provide new genetic knowledge and novel breeding technologies for perennial ryegrasses, fescues and clovers, coupled with delivery of existing scientific outputs into commercialisation.

Molecular technologies for wheat and barley

MPBCRC research contributes to molecular breeding of wheat and barley through the development and application of new molecular technologies, new molecular markers and new approaches for genetic analysis and molecular breeding in cereal crops. Solid-phase DNA markers have been validated for use in wheat and barley programs and additional markers have been converted to solid-phase formats. Multiplex-ready marker technology has been developed and is now deployed in MPB laboratories for low cost, high throughput assays of large numbers of microsatellite (SSR) markers in cereals. Proteomic technologies are being applied in wheat and barley, with MALDI-TOF and PAGE gel assays established to resolve gliadins and high molecular weight glutenin subunits in wheat. With low cost, high throughput DNA marker technologies, it has been possible to genotype large numbers of markers for genetic analysis and molecular breeding in wheat and barley, in projects involving association mapping, whole-genome analysis and selection, estimation of gene effects for cross prediction, genetic analysis of wheat germplasm derived from synthetic hexaploids and male-sterile facilitated recurrent selection. Furthermore, genome sequencing, comparative genomics and map-based cloning approaches are being applied for gene discovery. MPBCRC's research on molecular technologies for wheat

and barley attracts significant external funding, notably from the Australian Winter Cereals Molecular Marker Program of the GRDC.

Future plans include extension of DNA technology research to further reduce marker genotyping costs and to develop limited-sequencing approaches for SNP discovery and transcriptome analysis. Novel technologies will be applied to discover and develop high value markers for wheat and barley breeding. In wheat, the effectiveness and cost of MALDI-TOF protein profiling techniques will be evaluated relative to standard methods used for typing variants of key proteins affecting end-use quality. In barley, protein profiling will be used to define biomarkers for malting quality characteristics.

Molecular plant breeding information

As new molecular technologies produce increasing amounts of information, researchers require new methods, tools and resources to manage, analyse, integrate and interpret data. Research in Program 2 addresses this challenge through the development and implementation of web-based bioinformatics software and data resources, through activities in the areas of curation, accessibility and communications, through analysis of genetic data and through development of software tools for cross prediction and for simulation of molecular plant breeding.

MPB bioinformatics activities have provided customised web-based tools for storing, sharing and comparing genetic linkage maps (CMap), for storing, viewing, searching and curating pedigree data and to support implementation of MPB's multiplex-ready SSR marker technology (BINNER). An integrated suite of tools for storing, searching and screening marker genotype data is now under development and bioinformatics pipelines have been put in place for the assembly and annotation of wheat genome sequence information. MPB's gene effect estimates and Cross Predictor software are used routinely by collaborating wheat breeding programs to select parents and crosses. They have had a significant impact on Australian wheat breeding programs, increasing the probability that lines will meet grain quality standards and accelerating rates for disease resistance and grain yield by reducing the frequencies of lines in the programs that do not meet grain quality standards. In 2005-06, new projects were established to contribute to data curation and analysis and to develop software for the simulation of crossing and selection processes in molecular plant breeding.

Featured project report

2.1.03 Rice-wheat-barley comparative genomics for key agronomic traits

Leader: Prof Rudi Appels

Under certain environmental conditions, some varieties of wheat produce the enzyme alpha-amylase late in grain ripening, even in the absence of rain or sprouting. The resulting grain may appear sound, but can be unsuitable for end-product applications because late-maturity alpha-amylase (LMA) degrades starch. Reduction of LMA is a high priority in Western Australian wheat breeding programs. These programs want to be able to apply marker-assisted selection using DNA markers that are closely linked to the genes affecting LMA. This project has taken a genomics approach to investigate a region on wheat chromosome 7BL in which DNA markers for LMA, called QTLs, have been mapped. The research draws upon our understanding of the rice genome to point out areas of wheat DNA likely to be involved with LMA production. Molecular probes are then used to isolate genomic DNA clones, 'Bacterial Artificial Chromosome' (BAC) clones, corresponding to this region.

A two-step bioinformatics strategy has been used. Firstly, portions of the wheat and rice genomes were aligned to identify rice genomic regions analogous or 'syntenic' to wheat group 7L. Then candidate genes from those regions of the rice genome were selected. The selected candidate genes included an anion transporter as a candidate gene for boron tolerance, and GAMYB-like genes as candidate genes for LMA. The GAMYB class of transcription factors is of particular interest because published literature has indicated its importance in controlling alpha-amylase levels in cereal grains.

DNA markers and candidate genes were then used to screen two BAC libraries, one derived from the French wheat cultivar 'Renan' and the other derived from *Aegilops tauschii* (the source of the D genome of wheat). About 300 BAC clones corresponding to the chromosome region of interest were obtained and 24 of these were sequenced, allowing the development of new microsatellite and SNP markers. This also led to the discovery of novel transposable elements that could provide a rich source of polymorphism for the development of additional markers. New markers derived from BAC sequence information will be used to anchor the BAC clones to the genetic map and develop an integrated physical-genetic map. An automated annotation pipeline has been established and used to annotate 24 of the BAC clones. Highlights from the results of this work include annotation of MYB and GAMYB-like genes, along with the complete genomic sequence of a starch branching enzyme gene (sbe1).

Eight new microsatellite and SNP markers have now been mapped onto chromosomes 7AL, 7BL and 7DL, using the Cranbrook/Halberd mapping population. The 7BL and 3BS LMA QTLs have been validated in the Pastor/RAC891 mapping population. Multiplex Trait Signature (MuTs) analysis was developed and tested. MuTs provides a graphical genotype of individuals for a particular chromosomal region, providing a convenient tool for interrogating genetic similarity. Based on assays of 22 markers on 39 wheat cultivars of known LMA phenotype, we found that MuTs analysis can be used to group varieties according to their pedigrees and to infer LMA status of varieties.

Researchers: Meredith Carter (student), Prof Rudi Appels, Prof Mike Jones, Prof Matthew Bellgard, Dr David Dunn, Dr Xiuying Kong (Chinese Academy of Agricultural Sciences, Beijing).

PROGRAM 3 Markers and genetic solutions

PROGRAM LEADER: Dr Hugh Wallwork

Objectives

Program 3 aims to gain an improved understanding of the genetic control of key traits affecting wheat and barley production and grain quality. The focus of the program has been on abiotic stress tolerance whilst also investing significantly in quality and disease resistance.

In 2005 the wheat quality work in Program 3 received a significant boost. Drawing together work already under way in MPBCRC on wheat quality proteins, research into yellow alkaline noodles and other exploratory work on improved starch quality at the Waite Campus, MPBCRC won funding from the South Australian Premier's Science and Research Fund (PSRF) to further develop this research as part of a larger integrated program to identify avenues for adding value to wheat production in South Australia. This new program will expand on the existing research, which will also benefit other regions of Australia, whilst also investigating ways to enhance quality through identifying the genetic control of flavour and the biofortification of wheat with improved micronutrient levels.

A second component of the PSRF project is to boost the higher value durum industry. The area sown to durum has been declining rapidly due to problems with the crown rot fungus. An MPB project has identified effective resistance to this disease in a related grass species and this is currently being transferred into a more adapted durum background. Results from 2005 have shown that the transfer is proving successful, and so now, with the extra PSRF funding, this resistance is being fast-tracked into high yielding adapted varieties. This work is being coordinated with quality research which is identifying improved pasta colour so that the crown rot resistance and improved colour traits can be merged for future varieties.

A major feature of Program 3 is the development of improved knowledge of abiotic stress tolerance in wheat, an area identified by the Australian government as a national research priority. Research into tolerance to drought and hostile soils is now in full swing, with an Australian/CIMMYT mapping population being phenotyped and yield tested at four sites across South Australia and New South Wales as well as in Mexico (irrigated and drought conditions) and Kazakhstan. Later this year new trials will also be conducted in India and Morocco using CIMMYT collaborators. Further sites will be included in 2007 as more seed becomes available. Data have and will be collected for a range of physiological traits and tolerance to specific hostile soil conditions. Economic values will be generated in different characterised environments for a variety of QTLs identified through the merging of screening and genotyping data sets.

Work on waterlogging has revealed that this is a complex problem that is strongly influenced by soil type, in that different soils result in quite different responses from different varieties. Whilst this makes the development of waterlogging tolerant varieties considerably harder, the complexity and causes of earlier frustration are at least being revealed, leaving open the way to new avenues for tackling this problem.

Wheat and barley genetic maps and marker trait associations are continually being developed and improved. New technologies from Program 2 are being adopted and improved quality control procedures implemented for mapping projects. These improvements are rapidly being adopted for use in the marker-assisted selection labs working for MPB associated breeding programs.

Disease resistance and pathogen research is being boosted by the formation of a coordinated barley pathogen group. This comprises research into the genomics of host resistance, pathogen variation and investigations into the physiology and biochemistry of host-parasite interactions. This is underpinned by excellent resources and expertise with pathogen isolates and field pathology.

With funding from ABB Pty Ltd, three related germplasm development projects are using molecular markers and other more traditional screening tools to fast track the development of germplasm that combines elite malting quality alleles with robust disease resistance and adaptation. A number of derived lines from this work are now entering advanced yield trials and malt quality evaluation.

Featured project report

3.2.01g
Using novel glutenin alleles to improve wheat quality

Principal Researcher: Dr Marie Appelbee

The process of bread making depends to a large extent on the elastic properties of doughs. Too much elasticity and the loaf will not expand. Too little elasticity and the gas will escape leaving an uneven mass of holes. The perfect loaf of bread requires the right balance of viscosity and elasticity.

The elastic properties of bread wheat doughs result primarily from the presence of gluten proteins – storage proteins that make up about 85% of the total protein contained within the grain. Gluten in turn is made up of proteins known as gliadins and glutenins. Previous studies have shown that certain glutenin subunits have a major effect on dough strength, an important factor in bread-making. This study is examining the genetic determinants of dough strength so that cereal breeders can ensure that new bread wheat varieties will have optimal characteristics for baking.

Glutenins consist of high molecular weight-glutenin subunits (HMW-GSs) and low molecular weight-glutenin subunits (LMW-GSs) encoded at the Glu-1 and Glu-3 loci, respectively. Both Glu-1 and Glu-3 alleles convey additive gene effects and those which positively contribute to dough strength (Rmax and Ext) can be accumulated to improve wheat quality as it relates to bread making potential.

This project investigates the quality potential of grain proteins in different wheat species and aims to deliver outcomes such as the identification of novel glutenin alleles present in wheat relatives, development of elite quality germplasm, improved methods for glutenin identification, small scale quality tests, molecular markers to assist the selection of desirable alleles in early generations, and ultimately, greater returns to growers through higher AWB market classifications for new wheat varieties.

This research uses a set of isogenic substitution lines that comprise a large number of glutenin alleles. Field trials and quality testing of this material have enabled the identification of glutenin alleles whose frequency in Australian germplasm should be increased. Introgression of these alleles would provide the quickest route to improved end-use quality, the advantage being that they are already present in a well-adapted background. New isolines containing double and triple glutenin allele substitutions have been produced as well as numerous fixed lines having combinations of bread wheat Glu-1 and Glu-3 alleles that are associated with high dough strength, some of which are typically not present in Australian germplasm. Wider crosses involving novel glutenin alleles identified in related wheat species have also been conducted. The value of related wheat species as a source of new genes has been recognised in wheat breeding programs and many protein alleles present in under-exploited wheat relatives could enhance the bread making quality of current bread wheat cultivars. Related species that have been investigated include synthetic hexaploid lines (durum x *T. tauschii*), hexaploid landraces, *T. tauschii* and *T. dicoccoides*. Considerable progress has been made in screening this germplasm for protein quality attributes and transferring potentially desirable novel glutenin alleles into well-adapted germplasm.

Of the lines developed involving wider crosses, two contain, unlike bread wheat, both Glu-A1 x- and y-type subunits. This allele has been sourced from a *T. aestivum* ssp *spelta* accession and could have a large impact on wheat quality since it increases the number of HMW-GSs able to participate in effective protein entanglements. Similarly, cereal rye also contains interchain disulfide-linked proteins. The 75 γ-secalins are controlled by the Sec-2 locus located on chromosome arm 2RS. Gabo 2BL.2RS translocation lines have been produced by Dr Ken Shepherd and are being used in this project to increase polymeric protein. Unlike 1B.1R rye translocation lines these lines express Sec-2 proteins in addition to Glu-1 and Glu-3 proteins. Other lines being produced possess Glu-A1, Glu-B1 and high Gpc-B1 (high protein) alleles from *T. dicoccoides*.

Researcher: Dr Marie Appelbee

EDUCATION AND TRAINING

PROGRAM LEADER: Dr Amanda Able

The primary mission of the Education and Training Program is to ensure that Australian cropping industries are internationally competitive by having world-class plant breeders and scientists who use innovative biotechnologies and enjoy strong community support. We are currently addressing this aim through three subprograms: schools and community education, tertiary education and MPB professional training. By providing this continuum of education to all groups, we hope to provide career paths to agriculture (and in particular, plant breeding and biotechnology) and knowledge to the community about our research.

Community Education

Outreach activities with the wider community and schools have involved a significant collaboration with ACPFG to develop a number of educational packages including *Get into Genes*, the *Gene Juice Bar* and *Beer: Barley to Bottle*.

The biotechnology workshop *Get into Genes* became fully operational in South Australia in early 2005 and in Victoria from May 2006 following the appointment of Ms Marie Thorpe as *Get into Genes* Education Officer in January. Since its inception over 3,000 secondary school students have participated in *Get into Genes*. For their much appreciated role in the delivery and development of the workshop, MPBCRC Education Manager Dr Heather Bray and ACPFG Communications & Education Manager Ms Belinda Barr were finalists in the 2005 South Australian Premier's Science Excellence Awards for Science Educator of the Year. Furthermore, the entire *Get into Genes* team was recognised with a 2006 CRC Association Award for Excellence in Innovation in Education and Training and Public Outreach Activities.

We have presented the *Gene Juice Bar* at various events in 2005-06 including the Sydney Royal Easter Show. This bright, fun display uses DNA extraction experiments involving various fruits and vegetables as well as the provision of fact sheets to explain DNA and its importance to agricultural science.

During National Science Week 2005, our quiz night *Beer: Barley to Bottle* was run in both rural and metropolitan locations. MPBCRC has also been involved in field days such as the Birchip Cropping Group Grains Expo in Victoria and Dowerin Field Days in WA. Stands at these field days have involved DNA extractions and a display of the role that gluten plays in bread dough development. A number of our scientists were also involved in open forums on GMOs, events such as *Science in the Pub*, career nights and hosting work experience students.

School projects

MPBCRC has been very active in the schools area. Collaboration with ACPFG on many of these activities has enabled resources to be shared between the organisations for mutual benefit. MPB has given a number of presentations to teacher groups including participation in the National Science Teachers Conference (CONASTA) in July 2005 and the Science Teachers Association of Victoria Conference (STAVCON) in November 2005. The MPB Education team also fielded questions from Open Access College students in an online discussion forum about GM foods, ethics and its future.

MPB participated in both a scoping study and a National Workshop of the Promotion of Agriculture to Schools Network in late 2005. The network aims to develop a national strategy and cooperative approach to the promotion of agriculture to schools

During 2005, Liz Hope of Urrbrae Agricultural High School, on a Premier's Industry Placement Award for Teachers of Science and Mathematics, worked with MPBCRC to develop a series of year ten genetics curriculum packages.

MPB Training

MPB Training has been active with two major workshops/short courses held this year: Molecular Mapping Techniques in Diagnostic Biotechnology (Murdoch) and Systems Biology – From Single Cells to Environments (DPI Victoria).

The DVD on Molecular Techniques, developed in association with TAFE SA, is also progressing well. Filming has now been completed for the DVD and the animation is on track. It is envisaged that the DVD will become a key teaching and learning tool within the biotechnology industry and will enhance the value of current training activities. A marketing/ commercialisation strategy is currently being developed while the final product is being completed.

Tertiary education

Tertiary recruitment activities continue to take the form of attendance at career fairs and campus-based BBQs. Over 2005-06, ten undergraduate research scheme scholarships were awarded to undergraduate students. The program is designed to expose students to research and provide opportunities for them to network and develop contacts within plant breeding and plant biotechnology. In 2005-06, there were six Honours students working within MPBCRC.

Nine PhD students have finished in the last year bringing the total number of students graduated from MPBCRC/ CRCMPB to 36. Another six students are due to submit with 23 students having started their PhD with MPBCRC since July 2003. The majority of our students have industry and government supervisors (DPI Victoria, AGT or SARDI).

A postgraduate and Honours student retreat was once again held in conjunction with the Annual Research Conference in July 2005. The program included workshops on intellectual property, oral presentation, writing skills, time management and career path exploration. Linking in with these topics, recent editions of the student newsletter have included feature articles exploring aspects of postgraduate student training, such as dealing with anxiety associated with oral presentations or managing timely submission. The student newsletter is distributed every three to four months, with students willing to contribute news and information for circulation to their peers.

Members of MPB have been involved in the development of a new Masters program in plant biotechnology at The University of Adelaide due to begin early 2007. The MPBCRC Education Program Leader will coordinate this program.

Education Officer Marie Thorpe

STUDENTS COMPLETED 2005-06

Students completed 2005-06					
Name	**Title**	**Institution**	**Supervisor**	**Funding**	**Program**
Jaye Chalmers	Functional genomics of fructan biosynthesis in grasses	DPI - PBC / LaTrobe	Prof German Spangenberg	MPBCRC	1.1.11a
Jacinda Rethus	Transformation of wheat with a gene of industry significance and studies on the expression of that gene	DPI - Horsham / MU	Prof Geoff Fincher, Dr Jim Kollmorgen	APA / MPB-CRC	CG5.01
Nathanial Bannan	Strategies for marker assisted selection in outcrossing pasture species	DPI - Horsham / MU	Dr Kevin Smith	MPBCRC	2.1.02
Kate Shields	Grass endophyte genomics	DPI - PBC / LaTrobe	Prof German Spangenberg	MPBCRC	1.1.11c
Maria-Jane Appelbee (nee Vawser)	Assessment of the quality potential of endosperm storage protein alleles in hexaploid bread wheat relatives	UA / SARDI	Mr Geoff Cornish, Dr Tony Rathjen	APA MPBCRC	3.2.01g
Marc Ramsperger	Grass endophyte genomics	DPI - PBC / LaTrobe	Prof German Spangenberg	MPBCRC	1.1.11c
Emma Ludlow	Virus induced gene silencing in white clover as a tool in functional genomics	DPI - PBC / LaTrobe	Prof German Spangenberg	DA	1.1.11
Meredith Carter	Genome-level studies on agronomically important regions in wheat	Murdoch / DAFWA	Prof Rudi Appels, Prof Mike Jones	GRDC	2.1.05
Sherri Kruger	Development of association mapping technologies	UA	Prof Peter Langridge, Dr Jason Able	MPBCRC	2.2.03b

COMMUNICATION

Visiting dignitaries at the combined Gramina / VABC launch (From left: Minister for Agriculture, Bob Cameron; MPB Research Director, Prof German Spangenberg; Victorian Premier, The Hon Steve Bracks; Innovation Minister, The Hon John Brumby; Vice Chancellor La Trobe University, Prof Brian Stoddart.)

MPBCRC recognises three key areas of emphasis within its communication strategy:

- Internal: MPB researchers, students and commercial partners
- External: general public, schools, media
- Research: other researchers and potential collaborators.

Internal communication tools such as the quarterly newsletter *On the Mark* continued to highlight the events, research developments and community outreach activities of the CRC. The newsletter is distributed to MPB participants via email, posted on the MPB website and produced in hard copy for distribution at MPB events.

The Annual Research Conference is another opportunity for researchers and stakeholders to be updated on the activities of the other CRC participants. This year the meeting was again held in Ballarat, Victoria, and was attended by 115 MPBCRC participants. The Education Program Team, of which the Communication Manager is a member, held a Student Retreat for the second year running. A particular focus this year was on presentation skills.

Regular face to face meetings are key to effective stakeholder engagement. The MPBCRC CEO continued to be based at both the Adelaide and Melbourne nodes and visit the Perth node as appropriate. Additional stakeholder briefings were held as required. Similarly, the Board continued to meet at a different research node for each Board meeting.

A particular communication highlight for the year was the combined launch of Gramina Pty Ltd and the Victorian AgriBiosciences Centre. The launch was presided over by the Victorian Premier The Hon Steve Bracks and Innovation Minister The Hon John Brumby. The event was well attended by industry representatives, research partners and the media.

Communication to the general public of MPBCRC's research outputs continued through participation in rural events, interaction with the media and public presentations to schools, community groups and teachers. The media exposure of the CRC has been significantly expanded, with the number of CRC-related articles more than doubling from last year.

PUBLICATIONS

Refereed journal articles

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SPECIFIED PERSONNEL

Dr Bryan Whan
Chief Executive Officer
(Jul-Dec 2005)

Mr Jonathan Fenwick
Commercial Officer

Dr Glenn Tong
Chief Executive Officer
(Feb 2006 -)

Mr Michael McLean
Communications Manager

Dr Heather Bray
Education Manager

Mrs Nora Veljanovski
Administration Officer

Ms Vicki Kokolakis
Accountant

Ms Elizabeth Walsh
Administration Officer

Ms Cheryl McCaffery
Commercial Director

Mr Frank Yardley
Business Manager

The administration of the Molecular Plant Breeding CRC is conducted by a small team spread across two locations:

- Victorian AgriBiosciences Centre, Bundoora, Vic
- University of Adelaide, Waite Campus, Urrbrae, SA.

Together, they work closely with and support 204 staff who contribute to the activities of the Centre. Of this group, 124 are funded by MPBCRC and 52 are in-kind contributions made by partners of the Centre. Twenty-eight participants are funded through grants provided by bodies such as GRDC.

PERFORMANCE MEASURES

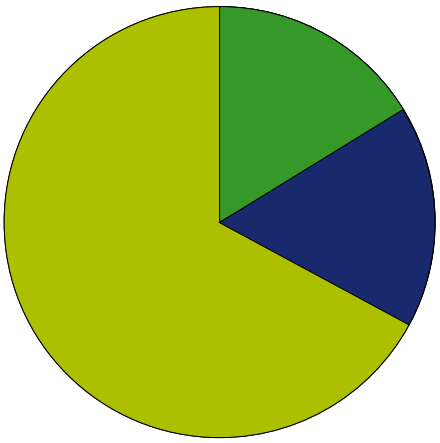
Performance measure	03–04	04–05	05–06
1. Collaborative arrangements Objective: Enhance collaboration among researchers and industry, and use IP and other resources more effectively.			
Extent of collaboration of participants within MPBCRC programs			
Number of projects with more than one participant (%)	72	77	62
Extent of national and international collaboration with non-participant organisations			
Agreements	1	0	2
National collaborations	7	18	25
International collaborations	17	24	27
Interactions with R&D Corporations and other funding bodies			
Number of projects with funding from R&D Corporations	15	25	19
Interactions and involvement of industry			
Number of projects with industry funding	3	9	9
Number of projects with industry involvement	9	9	10
Attendance at Annual Research Meetings			
Number attending	104	118	115
2. Research and development Objective: Establish, develop and undertake world-class, high-quality, industry-focused collaborative research programs in molecular breeding for cereals and pastures.			
Effective research portfolio that is output-focused and relevant to industry needs			
Number of refereed journal publications	88*	26	52
Number of refereed conference papers	85	57	106
Number of book chapters	13	16	13
Number of books	0	0	1
Effective procedures to assess research portfolio			
Progress reports submitted (%)	100	100	100
Reviews conducted	1	1	0
New projects developed	10	6	5
Achievements of research outputs according to target milestones for current year			
Output milestones met (%)	90	95	95
Number of events demonstrating national and international recognition of Centre staff			
Invited lectures and conference participations	38	78	49
Involvement in advisory roles	10	14	11
Success in attracting research and commercial funding from external bodies			
Number of new external grants	3	12	6
Value of additional external grants	$1,110,000	$2,051,837	$1,830,772
Total value of external grants	$3,942,000	$4,378,307	$4,791,183
3. Technology transfer Objective: Commercialise products of CRC research for benefit to Australia and beyond, providing return on investment, where appropriate.			
Capture of IP using legal means			
Internal disclosures for patentability/protection assessment	2	2	3
New provisional patent filings	0	1	1

* 03-04 column includes refereed journal articles that had been submitted for publication, but not yet published by June 30 2004. Subsequent years include only published articles.

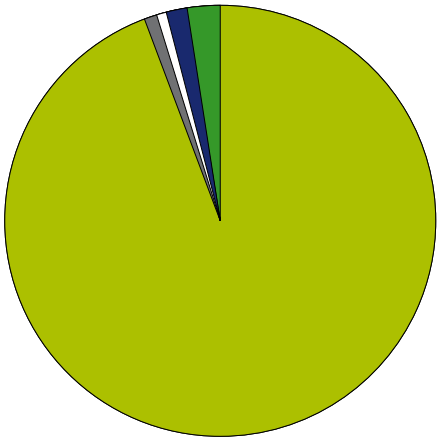
Performance measure	03–04	04–05	05–06
Complete applications filed	1	1	1
Patent applications in prosecution/ being maintained	22	23	29
Patents accepted/allowed	0	4	9
Commercialisation: technology development and licensing			
Research licences for MPB technology entered into	4	0	10
Confidentiality agreements executed for the purposes of confidential negotiations regarding business development	5	5	3
Collaborative R&D agreements entered into	1	10	9
Licensing agreements entered into	1	6	5
Agreements with end users vis-à-vis technology development and commercialisation	2	4	1
Impact on varieties developed using MPB technologies			
Number of objectives met by germplasm development	11	19	20
4. Education and training Objective: Entice and train excellent plant breeders and researchers.			
Effective training of postgraduate students			
Postgraduates enrolled	41	39	25
Total postgraduates completed (CRCMPB/MPBCRC)	25	27	36
Additional training opportunities provided	1	1	1
Students with non-university co-supervisor (%)	83	59	52

Performance measure	03–04	04–05	05–06
Training for people already working in plant breeding			
Training opportunities provided	2	2	2
School activities			
School education activities	7	32	57
Teacher training activities	9	3	5
Community awareness activities			
Community education activities	4	4	14
Overseas experience			
Number of overseas visits for staff and students supported	3	3	5
5. Communications Objective: Promote MPB's profile as a globally reputable organisation and foster ownership by the Participants.			
Internal communication activities			
Newsletters issued	0	3	4
Staff surveys/formal feedback forums	0	2	2
External communication activities			
MPB publications	1	7	8
Sponsorship of MPB-related activities	3	4	4
Visits to Centre website (page views)	1,731	46,347	31,445
Activities of Centre staff in media, field days and other communication activities			
Media appearances (print, radio and TV)	19	27	76
Attendance at field days and industry forums	8	21	16

SUMMARY OF RESOURCES



Funding sources	
Cash from grant	$4,940,000
Cash from participants	$4,471,000
Other income	$3,000
In-kind from participants	$20,276,000



Funding applications	
Research projects	$28,037,000
Education	$365,000
Communications	$233,000
Commercialisation	$378,000
Administration	$677,000

Financial information

A full account of MPBCRC's in-kind contributions, cash contributions and resources have been prepared in accordance with DEST guidelines and are available upon request.

Chartered Accountants
& Business Advisers

INDEPENDENT AUDIT REPORT TO

**THE DEPARTMENT OF EDUCATION, SCIENCE AND TRAINING,
REPRESENTING THE COMMONWEALTH,
IN RESPECT OF THE MOLECULAR PLANT BREEDING COOPERATIVE RESEARCH CENTRE
FOR THE YEAR ENDED 30 JUNE 2006**

Scope

We have audited the financial information of the Molecular Plant Breeding Cooperative Research Centre, as set out in Tables 1, 2 and 3 prepared on a cash basis for the year ended 30 June 2006, together with having addressed the specific contractual requirements of the Cooperative Research Centre under the Agreement dated 9th September 2003 with the Commonwealth of Australia (the Commonwealth Agreement) as specified by the Commonwealth of Australia's representative the Department of Education, Science and Training.

The parties to the Cooperative Research Centre are responsible for the preparation and presentation of the financial information and for its adherence to the Commonwealth Agreement. We have conducted an independent audit of the financial information and of the specific contractual requirements of the Cooperative Research Centre under the Commonwealth Agreement as specified by its representative the Department of Education, Science and Training, in order to express an opinion on the financial information and on those specific contractual requirements of the Cooperative Research Centre under the Commonwealth Agreement to the Department of Education, Science and Training. The financial information has been prepared for the purposes of fulfilling the Cooperative Research Centre's annual reporting obligations to the Department of Education, Science and Training under Clause 13 of the Commonwealth Agreement. We disclaim any assumption of responsibility for any reliance on this report, or on the financial information to which it relates, to any person other than the Department of Education, Science and Training or for any purpose other than that for which it was prepared.

Our audit has been conducted in accordance with Australian auditing standards to provide reasonable assurance as to whether the financial information is free of material misstatement and to address the specific contractual requirements of the Cooperative Research Centre under the Commonwealth Agreement as specified by its representative the Department of Education, Science and Training. Our procedures included examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial information and the evaluation of accounting policies and significant accounting estimates, together with addressing the specific contractual requirements of the Cooperative Research Centre under the Commonwealth Agreement as specified by its representative the Department of Education, Science and Training. These procedures have been undertaken to form an opinion whether, in all material respects, the Cooperative Research Centre's sources of funding and the application of that funding for the year ended 30 June 2006 and its financial position as at 30 June 2006 are presented fairly in accordance with Australian accounting concepts and standards and the Commonwealth Agreement and that the Cooperative Research Centre has complied with the following specific contractual requirements of the Cooperative Research Centre under the Commonwealth Agreement as specified by the Department of Education, Science and Training:

- Contributions, both cash and in-kind, have been made and recorded in accordance with the Budget, being Schedule 3 to the Commonwealth Agreement;
- Cash contributions have been paid into and expended from the Cooperative Research Centre's account as required by Clauses 4 and 7 of the Commonwealth Agreement;
- The application of Commonwealth Funding and Contributions for the Activities of the Cooperative Research Centre has been as specified in Clause 5 of the Commonwealth Agreement;
- The Cooperative Research Centre has met its obligations in relation to the treatment of Heads of Expenditure and Capital Items under Clauses 3 and 5 of the Commonwealth Agreement and Intellectual Property under Clause 9 of the Commonwealth Agreement; and
- In accounting for Commonwealth Funding and Contributions the Cooperative Research Centre has exercised proper accounting standards and controls as required under Clause 7 of the Commonwealth Agreement.

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PKF

Chartered Accountants
& Business Advisers

The audit opinion expressed in this report has been formed on the above basis.

Audit Opinion

In our opinion, the financial information presents fairly, in accordance with Australian accounting concepts and standards, the Molecular Plant Breeding Cooperative Research Centre's sources of funding and the application of that funding for the year ended 30 June 2006 and its financial position as at 30 June 2006.

It is further our opinion, in relation to the specific contractual requirements of the Cooperative Research Centre under the Commonwealth Agreement with the Commonwealth of Australia as specified by the Department of Education, Science and Training that:

- Contributions, both cash and in-kind, have been made and recorded in accordance with the Budget, being Schedule 3 to the Commonwealth Agreement, with the following exception where the Contributions was below the amount committed:

Organisation	Amount Committed $	Amount Contributed $
International Maize and Wheat Improvement Centre	963,000	719,000

- Cash contributions have been paid into and expended from the Cooperative Research Centre's account as required by Clauses 4 and 7 of the Commonwealth Agreement;
- The application of Commonwealth Funding and Contributions for the Activities of the Cooperative Research Centre have been as specified in Clause 5 of the Commonwealth Agreement;
- The Cooperative Research Centre has not met its obligations in relation to the treatment of Heads of Expenditure under Clause 3.5 of the Commonwealth Agreement in that the Researcher's allocations of the budgetary resources between the Heads of Expenditure have been lower or higher than the allocation in the budget by $100,000 or 20%, whichever is the greater amount, without the prior approval of the Commonwealth. The variations relate to salaries expenditure, where actual expenditure of $5,546,000 exceeded budgeted expenditure of $4,612,000 by $934,000, and other expenditure, where actual expenditure of $3,773,000 exceeded budgeted expenditure of $3,093,000 by $680,000. The Cooperative Research Centre has met its obligations in relation to the treatment of Capital Items under Clause 5.3 of the Commonwealth Agreement in that Capital Items acquired from the Grant and Contributions have been vested as provided in the Joint Venture Agreement, and in relation to Intellectual Property under Clause 9.1 of the Commonwealth Agreement in that we have seen a statement by the Chief Executive Officer to the effect that Intellectual Property in all Contract Material is vested as provided in the Joint Venture Agreement and no Intellectual Property in any Contract Material having the potential for Commercialisation has been assigned or licensed without prior approval of the Commonwealth; and
- In accounting for Commonwealth Funding and Contributions the Cooperative Research Centre has exercised proper accounting standards and controls as required under Clause 7 of the Commonwealth Agreement.

PKF
Chartered Accountants

I J Painter
Partner

Signed at Adelaide, this 28th day of September 2006.

SHORTENED FORMS

MPBCRC	Molecular Plant Breeding Cooperative Research Centre
ACPFG	Australian Centre for Plant Functional Genomics
AGT	Australian Grain Technologies
BAC	Bacterial artificial chromosome
BPS	BASF Plant Science
CIMMYT	International Maize and Wheat Improvement Centre
DA	Dairy Australia
DAFWA	Department of Agriculture and Food, Western Australia
DEST	Department of Education Science and Training
DPI Vic	Department of Primary Industries Victoria
GGDF	Geoffrey Gardiner Dairy Foundation
GM	Genetically modified / genetic modification
GRDC	Grains Research and Development Corporation
IP	Intellectual property
LMA	Late-maturity alpha-amylase
MLA	Meat and Livestock Australia
MU	Melbourne University
PBC	Plant Biotechnology Centre
PBR	Plant Breeders' Rights
PSRF	Premier's Science and Research Fund (South Australia)
QTL	Quantitative trait locus
SARDI	South Australian Research and Development Institute
SNP	Single-nucleotide polymorphism
SSR	Simple sequence repeat

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