Cooperative Research Centre for National Plant Biosecurity

Annual Report 2011 - 2012

CRC PLANTbiosecurity

biosecurity built on science

Our vision...

...is to be a world leader in the generation, development and delivery of plant biosecurity science and education.

Our mission...

...is to foster scientific collaboration and engage stakeholders to deliver plant biosecurity technologies that will reduce risk to, and ensure sustainability of, Australia's plant industries.

Cooperative Research Centre for National Plant Biosecurity

Address: Level 2, Building 22, Innovation Centre
University of Canberra, Bruce ACT 2617

Postal Address: LPO Box 5012, Bruce ACT 2617

Telephone: +61 2 6201 2882
Facsimile: +61 2 6201 5067
Email: info@crcplantbiosecurity.com.au
Website: www.crcplantbiosecurity.com.au

ABN: 13 115 589 707

Contents

Executive Summary

Achievements

Key highlights, awards and special commendations

Among the highlights from the 2011-12 reporting period was the continued recognition for the Remote Microscope Network (RMN). Together with the Plant Biosecurity Toolbox™ (PBT), the RMN is a world leader in providing time sensitive and accessible information on outbreaks of exotic plant pests and diseases through web-based diagnostic resources.

In recognition of this ground breaking work, the RMN project won two awards in 2011-12, in addition to the one received in 2010-11.

The awards were a Queensland Premier's Award for Excellence in Public Service Delivery – which won the Green category for protecting Queensland's lifestyle and environment – and *The Australian* Innovation Challenge Award in the Agriculture and Food sector.

The RMN links field officers with national and international experts, enabling a dramatic decrease in the time taken in identifying exotic insects and diseases which may pose a threat to crops and the environment in Australia.

Plant Biosecurity CRC bid

The CRC received the good news in November 2011 that it had been successful in its bid to secure further funding from the CRC Program until June 2018. The Plant Biosecurity CRC (PBCRC) will receive $29.7 million from the CRC funding over the six years and its 27 Participants from industry, government, universities, and international organisations will invest $102 million in cash and in-kind. New participants include, internationally, Kansas State University (USA), Plant and Food Research (New Zealand), the Bio-Protection Research Centre based at Lincoln University (New Zealand) and the Pacific Institute for Sustainable Development (Indonesia), and in Australia, the University of Queensland and Museum Victoria. The international involvement reflects the fact that plant biosecurity is a global issue.

Gary Kong receives *The Australian* Innovation Award from the Minister for Innovation, Industry, Science and Research, the Hon Kim Carr




Throughout the year a number of Chinese organisations visited the CRCNPB to sign MOUs

PhD candidates

At June 30 2012, the CRC had a portfolio of 33 postgraduate candidates. Of these, 16 candidates had successfully submitted their PhD theses. More than 50% of these graduates have found employment in plant biosecurity. These positions include many of the CRC Participant organisations, for example, DAFWA, QDAFF and DAFF Biosecurity.

The remaining 17 candidates continued to progress their studies and the CRC remains confident that it will fulfil the Commonwealth contracted commitment of 32 PhD graduates by the end of December 2012.

Visitors to the CRC

Over the year, the CRC hosted a wide range of Australian plant industry and scientific groups. It also hosted a number of international delegations. These included:

- United States:
  - Kansas State University delegation (Professor Kirk Schulz, President and Professor John Leslie, Head of the Department of Plant Pathology)
  - Washington State University delegation (Professor Prema Arasu, Provost and Associate Vice President, International Programs).
- China:
  - Chinese Academy of State Administration of Grain (CASAG), Beijing (delegation led by Professor Du Zheng, President)
  - Chinese Academy of Inspection and Quarantine (CAIQ), Beijing (delegation led by Professor Wang Yuejin, Director of Institute of Quarantine Treatment), and
  - North West Agricultural and Forestry University, Xian (delegation led by Professor Zhao Zhong, Executive Vice President).

Memoranda of Understanding (MOUs) were also signed with all three of these organisations during their visits to the CRC. These organisations provide the CRC with access to experts and facilities in areas that are highly relevant to our research. These MOUs will continue with the new Plant Biosecurity CRC.

- United Kingdom
- Kenya
- Thailand, and
- New Zealand

In addition to these delegations, the CRC organised or hosted a number of international workshops. These included a remote diagnostics Master Class in Kenya, remote diagnostics workshops in Thailand and an international digital diagnostics workshop with CABI and AusAid in Canberra.

The strong interest from these groups demonstrates the value and benefit they perceive in being associated with the CRC.

Science Exchange 2012

Our Science Exchange 2012 was held in the Swan Valley from 23-25 May. It was attended by 189 people, including researchers, PhD students, staff, the Board, Participants Committee, industry and government representatives. As in previous years, the Science Exchange was held over two and half days and offered plenty of opportunities for networking among researchers, with a focus on celebrating the successes of the previous seven years, as well as discussing future CRC research project ideas.

A number of meetings were held prior to the official start of the Science Exchange. These included a PhD field trip, Science Committee, Participants Committee and Board meetings and the signing of Memorandum of Understanding with three Chinese organisations.

There were 55 oral presentations and 18 scientific posters presented during the Science Exchange comprising eight different themes.

An Awards Dinner was also held during the Science Exchange at which a number of awards were presented to project teams and individuals who have made an outstanding contribution to plant biosecurity research. On behalf of the Science Committee, Dr David Eagling, CRCNPB Research Leader, presented the following awards:

- *Science Committee Award for Science Impact* – Biosensor-based detection of grain pests project team. Opportunities exist to apply new technologies to plant biosecurity. This research applied molecular approaches to identify biological detectors and signalling as the basis for a new approach to detect grain insects. It made a number of breakthroughs in the area of insect receptors and signalling, which are being used as proof of concept to drive the development of a new generation of biosensor devices. The project has published two papers in high impact journals and presented findings at three international symposia.
- *Science Committee Award for Biosecurity Impact* – Post-entry quarantine project team. Post entry quarantine is a fundamental part of the fabric of plant biosecurity. This research developed advanced diagnostic methods and tools for the detection of plant viruses, which can be quickly applied to both import and export situations. This project was a trans-Tasman initiative and has generated significant interest and support from both industry and government. The research has been supported through the respective federal biosecurity structures with the potential to make significant impacts on the time and cost associated with quarantine processes.

Science Exchange Awards Dinner 2012

- *Science Committee Award for Collaboration* – Ensuring effective phosphine application project team. Phosphine underpins the grain industry's capacity to trade. This project successfully brought the practical skills of commercial grain protection managers and commercial manufacturers together with the engineering and computer modelling abilities of scientists. With shared leadership between industry and CSIRO, the project made a number of recommendations for the application of phosphine which have been widely accepted and put into practice by industry.
- *Science Committee Award for Contribution to the CRC* – Jo Luck. Jo led large and successful CRC projects and worked hard to promote and explain CRC work to a broader audience. She engaged with the CRC office, often undertaking extra work beyond her core projects. She dealt successfully with complex contractual and funding situations in a positive good-humoured manner. Jo also took a key role in the CRC rebid with her involvement in the development of the exemplar projects.
- *Science Committee Award for Best Presentation* – Mark Schutze. Mark's presentation was entitled 'The resolution of species boundaries of four past members of the *Bactrocera dorsails* complex (Diptera: Tephritidae): a multidisciplinary approach'.

Other awards presented at the Science Exchange were:

- *Board Directors Award for Best Poster* – Philip Burrill. Philip's poster was entitled 'Measuring working airflow of aeration fans'.
- *People's Choice Award for Best Poster* – Anna Rathe. Anna's poster was entitled '*Homalodisca vitripennis* (Hemiptera: Cicadellidae) and *Xylella fastidiosa* (Proteobacteria: Xanthomonadaceae): potential Australian invaders'.

Key events and changes

During the reporting period there were the following changes to the staff in the CRC:

- Ms Priyanka Suryanarayanan was employed on a temporary part-time basis from July 2011 until June 2012 in the position of Publications Officer. The role will not be continuing in the Plant Biosecurity CRC.
- Mr Cain Roberts finished in his role of Delivery and Adoption Officer in June 2012. The role will not be continuing in the Plant Biosecurity CRC.
- Ms Bronwyn Jones filled the role of Administration Officer from August 2011 to June 2012 while Ms Alejandra Cano was on maternity leave.
- Mrs Marcia Murray was employed in a new Management Accountant position from February 2012.
- Dr Jo Luck and Dr Sharyn Taylor were employed in two new Program Coordinator positions from May 2012.

Risks and Impediments

The Board and management of the CRC have constructed a risk management matrix and regularly review all CRC activities. The overall risk of the CRC is low given the strong commitments of Participants, the progress of projects and the stability of staff and researchers. Accordingly, we have not experienced any major risks or impediments to achieving our objectives during the reporting period.

We continued to focus on delivering project outcomes, especially as projects reached maturity. The final reports from projects have been coming in and, as at 30 June 2012, there were only a few still outstanding. In addition, we have continued to ensure that our research outcomes are translating into impact for our end-users.

End-user Environment

As indicated in previous Annual Reports, the Australian grain industry has been operating in a deregulated environment since July 2008. Although this legislation has not directly affected the CRC or our ability to meet our objectives, the subsequent market structure changes have highlighted the increased risks in the export market. At the same time, our export markets have become more discriminating, requiring guarantees of the pest-free status of grain. This is further compounded by the growing phosphine resistance in grain pests which poses a serious threat to the competitiveness of Australian grain.

Through its *Program 5: Post-harvest Integrity Research* section, the CRC has been putting much effort into providing both long and short term solutions for industry in these areas.

This financial year has seen the horticultural industry come under increased pressure due to the ban on dimethoate, (a chemical routinely used for both pre-harvest and post-harvest control of crops) and the opening of Australian markets to New Zealand and Chinese apples.

The CRC's Research Programs remain well aligned with the changes occurring in plant industries. One of the strengths of the CRC is that all of the end-user groups – rural industry, state and Australian Governments – are heavily involved in the CRC itself. In addition, the majority of plant biosecurity entities participate in the CRC. These entities either are, or have direct contact with, direct users of CRC outputs. This allows the CRC to maintain sound knowledge of the on-going end-user environment and to react quickly if changes in this environment occur. In addition, the CRC has both Grains and Horticulture Advisory Panels that met several times last year to ensure the needs of our end-users are met.

Outcomes

Value of outcomes to date compared to the expectations in the Commonwealth Agreement

In the *Commonwealth Agreement*, it was noted that while pest incursions directly threaten the viability of Australia's plant industries, the cost varies considerably depending on whether the pest spreads widely or if it can be contained in certain areas and, if so, whether area freedom status can be achieved and recognised.

In response, we have focused on building scientific capability and delivering impact within the biosecurity framework that comprises prevention, identification and detection, surveillance, impact management and post-harvest integrity. During the current year there has been strong progress in all areas and outcomes are being extended in line with end-user priorities and expectations.

The outputs of the CRC are delivering economic, environmental and social benefits to Australia. However, as detailed in the *Commonwealth Agreement*, the majority of outputs from this CRC are knowledge-based products, for which it can be difficult to provide a monetary figure. In addition, it is difficult to know which pest or disease might next affect our plant industries or which industry will be next affected.

A good example of one of the CRC's outcomes is the results of the Alternatives to Phosphine project (CRC50147). The project looked at using nitrogen as an alternative to phosphine for killing stored grain insects. It found that high concentrations of nitrogen or low oxygen in canola kills all stages of all tested insects with higher efficacy. In addition, the canola seed colour, oil content and levels of free fatty acid did not change during the storage period. This storage process of canola significantly contributed to maintaining its quality. The use of nitrogen is very beneficial for canola exports as it prevents the degradation of oil quality that can be caused by oxidation.

Governance and Management

Governance – Board, Committees and Key Staff

Structure

CRCNPB is operated by CRC NPB Limited in accordance with the *Commonwealth Agreement* and *Participant Agreement*.

CRC NPB Limited is a Public Company limited by guarantee and, as such, must abide by the *Corporations Act*. Its activities are governed by its constitution which must be consistent with the *Participant Agreement* and the funding Agreement between the Commonwealth and the Participants. It is a taxable entity.

The Board of Directors of the Company are responsible for the corporate governance of the Company. The Board guides and monitors the business and affairs of the Company on behalf of the members by whom they are elected and to whom they are accountable.

CRCNPB Board

Our Board plans, develops and oversees delivery of our strategic objectives. The skills-based Board is made up of a Chair and six other Directors, who are all independent of our Participants. The Board also undergoes an annual Board performance review.

The Board was established with careful consideration ensuring a broad field of expertise to maximise the value of the Board's input into our direction and management. There were no changes to the Board membership during the reporting period.

At the 2011 Annual General meeting (AGM), the tenure for three Directors (Mr Chris Richardson, Dr Jim Cullen and Mr John Sandow) was due to expire. All three retiring directors re-nominated for the vacant Director positions and were reappointed to the Board of CRC NPB Ltd.

The names, qualifications and experience of the Board of Directors in office during the period and until the date of this report are detailed in the table on the following pages.

Governance/Management Issues

The CRC did not experience any governance or management issues during this reporting period.

One of the Chinese organisations the Board met with during the year was Northwest A&F University

Board Members

The table below provides details on the Directors of the CRC NPB Ltd.

Name	Role	Key skills	Independent/ Organisation
Professor John Lovett	Chair	Qualifications: BSc Hons (Agric), PhD, FBS, FAIAST, MAICD Chair, Agrifood Awareness Australia Ltd (2004-2011). Chair, CRC for Greenhouse Accounting (2004-2006). Board Member, Primary Industries Education Foundation (2009-2011). Board Member, HRZ Wheats Pty Ltd (2004-2006). Member Executive Board, Global Crop Diversity Trust (2006-present). Managing Director, Grains Research and Development Corporation (1994-2003). Managing Director, Lovett Associates Pty Ltd (2004-present). Professor of Agronomy, University of New England (1987-1993). Professor of Agricultural Science, University of Tasmania (1984-1987).	Independent
Mr Barry Windle	Deputy Chair	Qualifications: B AgS, Dip Hort Sci Chair, AFMA Great Australian Bight Trawl Fishery Management Advisory Committee (current). Member of Central NRM Group - Adelaide and Mount Lofty Ranges, NRM Board (current). Facilitator, Risk Management Review, SA Phylloxera and Grape Industry Board (current). Reviewer, Emergency Plant Pest Response Deed, PHA (2011). Executive Director, Agriculture, Food and Fisheries, Primary Industries and Resources SA; Executive and Policy roles: PIRSA (1988-2004), Horticultural Research Officer and related policy roles (1971-1988).	Independent
Ms Christine Campbell	Director	Qualifications: FCPA, GAICD Director (current), Executive Chairman (1999 to 2010), CEO (1986-1999), and Financial Controller (1977) Twynam Agricultural Group. Director, Lawson Grains Ltd (current). Chair, National Farmers' Federation Water Taskforce (2005-2006). Chair, Australian Cotton Industry Council (2002-2005). Member of Policy Council, National Farmers' Federation (2004-2005). Member of Executive Committee, National Farmers' Federation (2002-2004). Chair, Cotton Australia (2001-2003). Member of Private Sector Advisory Panel to International Cotton Advisory Council (2004-2005). Director, Cotton Australia (1999-2005).	Independent
Dr Jim Cullen	Director	Qualifications: BA (Hons), PhD Member, Quarantine & Exports Advisory Council (1997-2003). Chief, CSIRO Entomology (1997-2002). Board Member, CRC for Australian Weed Management (Weed Management Systems) (1995-2002) (Acting Director 1995). Member, Australian Weeds Committee (1988-2002). Founding President, ACT Branch, Australian French Association for Science and Technology (AFAS) (1991-1993). Director, Entocosm Pty Ltd, (2002-2004). External Advisor (Science & Research), Environmental Risk Management Authority NZ (2002). President, Australian Entomological Society (1997-2000).	Independent

Name	Role	Key skills	Independent/ Organisation
Professor John Irwin	Director	Qualifications: BSc Hons (Agric), MSc (Agric), PhD, DSc (Agric) Professor Emeritus, University of Queensland (2009-present). Editor in Chief, Crop and Pasture Science (formerly Australian Journal Agricultural Research) (2009-present). Professor, School Biological Science: University of Queensland (1993-2009). CEO, CRC for Tropical Plant Protection (1999-2006). CEO, CRC for Tropical Plant Pathology (1992-1999). Member, National Crop Improvement Committee, Grains Research and Development Corporation (1991-1993). Member, Oilseeds Research Council (1989-1991). Lecturer/Senior Lecturer/ Reader, University of Queensland (1982-1992). Plant Pathologist/ Research Fellow, Queensland Department of Primary Industries/University of Wisconsin (1972-1982).	Independent
Mr Chris Richardson	Director	Qualifications: Diploma in Agriculture, GAICD Chair, Biosecurity Council of WA (2008-2012). Chair, Agriculture Protection Board of WA (Board member since 1998 and Chair 2002-2010). Chair, WA Footrot Eradication Campaign Advisory Committee (1999-2011). Chair, WA Ovine Johnes Disease Advisory Committee (2004-2011). Board member, Corredene Pty Ltd. CEO, Australian Merino Society Inc (1999-2010).	Independent
Mr John Sandow	Director	Qualifications: BSc Hons, MSc, MAICD Director, Cooperative Research Centre for Australian Weed Management (2002-2008). Director, Western Australian Herbicide Resistance Initiative (WAHRI) (2002-2007). Member, Steering Committee "Grain Protection Genes" (GRDC/CSIRO joint venture) (2002-2007). GRDC Program Manager, Crop Protection (2002- 2007). Crop Care Australasia Pty Ltd - National Technical and Development Manager (2001-2002), Marketing Services Manager (2000-2001), Group Product Manager (1998-2000), Product management and technical roles (1989-1998). Entomologist, Western Australian Department of Agriculture (1979-1989).	Independent

Function and frequency of Board meetings

Our Board meets quarterly in various locations around Australia. During the 2011-12 financial year, there were four Board meetings. Attendance is indicated below:

Name	August 2011	November 2011	February 2012	May 2012
Professor John Lovett	Present	Present	Present	Present
Mr Barry Windle	Present	Present	Present	Present
Ms Christine Campbell	Present	Present	Present	Present
Dr Jim Cullen	Present	Present	Present	Present
Professor John Irwin	Present	Present	Present	Present
Mr Chris Richardson	Present	Present	Present	Present
Mr John Sandow	Present	Present	Present	Present

Board Committees

Finance and Audit Committee

The Finance and Audit Committee provides assistance to the Board of Directors in fulfilling its corporate governance and oversight responsibilities in relation to our financial reporting, internal control structure, risk management systems and external audit functions. It meets once a quarter, usually two to three weeks prior to a Board Meeting and by video or teleconference.

Name	Role	Key skills	Independent/ Organisation
Ms Christine Campbell	Chair	See details under Board	Independent
Professor John Irwin	Member	See details under Board	Independent
Mr Chris Richardson	Member	See details under Board	Independent

Board Nomination Committee

The Board Nomination Committee consults with the Participants and Directors to identify suitable candidates to the members for election as Directors. The Committee convened twice by teleconference in September 2010 in preparation for the AGM in November 2010.

Name	Role	Key skills	Independent/ Organisation
Professor John Lovett	Chair	See details under Board	CRCNPB
Dr Martin Barlass	Member	Qualifications: BSc Hons, MSc, PhD Chair: National Horticultural Research Network (2009-present); Participant Committee of the CRC National Plant Biosecurity (2008-present), Board member: Australian Biosecurity Intelligence Network (2008-present), Member: National Apple and Pear Advisory Committee, Director Science Innovation: Department of Primary Industries Victoria (2011-present), Deputy Executive Director: Biosciences Research, DPIV (2008-2011), Deputy Executive Director: Primary Industries Research Victoria, DPIV (2003-2007), Director: Agricultural Industries, Department of Natural Resources and Environment (2001-2003), Director: CRC for Viticulture (2002-2004), General Manager: Plant Industries, Agriculture Victoria, Department of Agriculture Victoria (1998-2001), Principal Scientist: Plant Biology, DAV (1992-1998), Manager R&D: Phytotech Pty Ltd. (1989-1992), Member: Dried Fruits Research and Development Council (1988-1994), Research Scientist: CSIRO Horticulture (1977-1989). Skills: plant virology, research management, science innovation, strategic planning.	Department of Primary Industries Victoria

Name	Role	Key skills	Independent/ Organisation
Mr Greg Fraser	Member	Qualifications: BScAg (Agronomy), MMgt (Strategy and Finance) CEO and Executive Director: Plant Health Australia (2008-current); Non-Executive Director: Australian Institute of Agricultural Science and Technology (2009-current); Fellow: Australian Institute of Company Directors (2007-current); Member Industry Advisory Committee (2005-2011); Executive Manager: Grains Research and Development Corporation (2005-2008).	PHA
Associate Professor Giles Hardy	Member	Qualifications: BSc Hons (Agric), PhD Plant Pathology Director: State Centre of Excellence for Climate Change, Woodland and Forest Health (2009-current); Centre for Phytophthora Science and Management (2003-current).	Murdoch University
Mr Ernestos Kostas	Member	Qualifications: BEnvSc (Biology) Manager: Grain Protection and Sealing, Co-operative Bulk Handling (2005-present); Member: Grains Advisory Panel (2008-present); Representative: Participants Committee, CRCNPB.	CBH Group
Adjunct Professor Shashi Sharma	Member	Qualifications: BSc, MSc, PhD Director: Plant Biosecurity Program, Department of Agriculture and Food, Western Australia. Adjunct Professor, Murdoch University. Chairman: WA Grains Industry Biosecurity Committee (GrainGuard) (2006-present); WA Horticulture Industry Biosecurity Committee (HortGuard) (2006-present); WA Bee Industry Consultative Committee (2009-present).Member: Australian Plant Health Committee (2001-present); CABI Program Advisory Board for Crop Protection, UK (1997-1999). Head and Professor: Division of Nematology, Indian Agriculture Research Institute, India (1999-2000). Scientist: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (1983-1998). International Fellow: Rothamsted International, UK (1994-1995). Visiting Professor: University of Missouri, USA (1993-1994). Skills: Biosecurity science, regulation and policy.	Department of Agriculture and Food WA
Dr Andy Sheppard	Member	Qualifications: BSc (Hons), PhD, DIC FRES CSIRO Senior Principal Research Scientist & Theme Leader Biosecurity (2006-present); Board Member: CRC for Australian Weed Management (2006-2008); Board Member of CABI (2002-2005); Member: Environmental Biosecurity Committee (2008-2010); Member: Plant Health Committee (2008-2010); Président : Centre International de Lutte Biologique Agropolis, Montpellier France 2003-2005; Australian Representative: Governing Body of the OECD Cooperative Research Programme (2002-2006); Australian Representative: Executive Council of CABI (2002-2006).	CSIRO

Key Staff

The table below details the key staff in the CRC in 2011-12.

Name	Organisation	CRC Position / Role	Time committed
Dr Simon McKirdy	CRCNPB	Chief Executive Officer	100%
Mr Nicholas Langley	CRCNPB	Business Manager	100%
Dr David Eagling	CRCNPB	Research Leader	100%
Mrs Max Knobel	CRCNPB	Communications Manager	100%
Dr Kirsty Bayliss	Murdoch University	Education and Training Leader	100%
Dr Paul De Barro (July-August) Dr Rieks van Klinken (August-present)	CSIRO	Program Leader	50%
Dr Pat Collins	DAFF Queensland (formerly DEEDI)	Program Leader	50%
Ms Jane Moran	Department of Primary Industries Victoria	Program Leader	50%
Dr Deb Hailstones	NSW Department of Primary Industries	Program Leader	50%

CRCNPB staff at the Science Exchange Awards Dinner. From left: Andrew Crichton, John Austen, Jo Luck, Nick Langley, David Eagling, Gary Kong, Simon McKirdy, Carla Tadich, Marcia Murray, Sharyn Taylor, Cain Roberts, John Lovett (Chair), Scott Baxter and Max Knobel

Participants

List of Participants during the reporting period

We have participants from all states and territories on mainland Australia and involve a majority of plant biosecurity specialists in the country.

Participant Name	Participant Type	ABN or ACN	Organisation Type (or Individual)
Department of Agriculture, Fisheries and Forestry	Core	24 113 085 695	Australian Government
CABI	Supporting	N/A	International
Charles Darwin University	Core	54 093 513 649	University
Charles Sturt University	Supporting	83 878 708 551	University
Co-operative Bulk Handling Ltd	Core	29 256 604 947	Industry
CSIRO Entomology	Core	41 687 119 230	Australian Government
Department of Agriculture and Food, Western Australia	Core	86 611 226 341	State Government
Department of Agriculture, Fisheries and Forestry, Queensland	Core	66 934 348 189	State Government
Department of Primary Industries, Victoria	Core	42 579 412 233	State Government
GrainCorp Ltd	Core	52 003 875 401	Industry
Grains Research and Development Corporation	Core	55 611 223 291	Industry
Horticulture Australia Ltd	Supporting	19 095 566 108	Industry
La Trobe University	Core	64 804 735 113	University
Murdoch University	Core	61 616 369 313	University
NSW Department of Primary Industries	Core	72 189 919 072	State Government
Northern Territory Department of Resources	Supporting	84 085 734 992	State Government
Plant Health Australia Ltd	Core	97 092 607 997	Other
Queensland University of Technology	Core	83 791 724 622	University
Saturn Biotech Limited	Core	36 096 225 508	Private Sector
South Australian Research and Development Institute	Core	53 763 159 658	State Government
Southern Cross University	Supporting	41 995 651 524	University
University of Adelaide	Supporting	61 249 878 937	University
University of Western Australia	Supporting	37 882 817 280	University
Viterra Ltd	Core	59 084 962 130	Industry

Changes to Participants

Saturn Biotech Limited ceased to be a Participant of the CRCNPB on 22 May 2012.

Financial Management

The CRCNPB's financial performance overall can be measured with reference to the level of expenditure on the CRC's Activities against the agreed expenditure documented in the *Commonwealth Agreement*. The CRC's Activity expenditure (see table 3 of the Financial Tables) in 2011-12 was $9.9 million. This was against a budgeted expenditure of $9.5 million and agreed expenditure under the *Commonwealth Agreement* of $8.2 million. The higher research expenditure reflects a catch-up on previous years' project underspends. This took the CRC's Activity expenditure for the life of the CRC to $55.6 million - $578,000 more than agreed for the life of the CRC.

Overall cash contributions accounted for by the CRC in 2011-12 were as follows:

Source	Amount (millions)
Cash from Participants	$4.55
Cash from DIISR	$4.30
Other firm cash	$0.69
In-kind – staff	$5.49
In-kind – non staff	$3.38
Total	**$18.41**

The CRC's cash balance at the end of June 2012 stood at $3.8 million, up on last year's balance of $3.1 million. This figure included $715,000 of funds received in advance for PBCRC. At 30 June the CRC had receivables due of $1.06 million.

All Participant contributions have been received by the CRC as expected bar one. Our smallest cash contributor ($9,000 p.a.) failed to make all four quarterly contributions during the year. This Participant was expelled from the CRC in May 2012. This has been reflected in our audited Annual Financial Report.

Communications

Communication activities continued to play an important role within the CRC throughout 2011-12 providing end-users, industry, researchers, government and growers with plant biosecurity information relevant to their needs. This year was particularly important given the amount of information regarding the CRC changing over from the CRCNPB to the PBCRC from 1 July 2012.

In a busy year, the Science Exchange had a record number of attendees; we continued to support industry and government events; a new website was developed for the PBCRC; and our interaction on social networking sites continued to grow.

In the latter part of the year there was a large intake of final reports submitted to meet the CRCNPB's deadline, all of which have been posted on the website. As a result the size of the website increased – as did the number of visitors – with over 24,000 visitors throughout the year from 164 countries. Seven editions of *The Leaflet* newsletter were also published, which on each occasion provided large peaks in website visitors, a sign of our stakeholders continued interest in plant biosecurity news.

Given *The Leaflet's* popularity, the Communications team launched a more frequent newsletter in 2012 – *The Bud* – which is emailed to stakeholders every fortnight and provides smaller snippets of news. Interest in *The Bud* is already strong, with over 300 subscribers signing up in the first two months.

Internal communication activities

In May we held our main event – the Science Exchange – which brought together the majority of people involved in the CRC. This year saw a record 189 delegates in attendance, which included international visitors from New Zealand, Indonesia, Thailand, China and the USA. This year's event was held at The Vines Resort in the Swan Valley, WA from 23-25 May. The exchange featured 55 presentations and 18 scientific poster displays.

Nearly 200 delegates attended the Science Exchange in 2012

External communication activities

Throughout 2011-12, we continued our support of plant-related industry conferences. The Australian Grains Industry Conference in July 2011 provided an opportunity to support one of our major industries while also raising biosecurity awareness.

We provided a stand at the Innovation in Australia Showcase in Brisbane in December 2011, where we displayed an unmanned aerial vehicle (UAV). The UAV provided a dramatic sight as it hung above our stand and attracted attention from the Minister for Innovation, Industry, Science and Research, the Hon Kim Carr.

The CRC was also on display to the Minister during National Science Week in August, where we demonstrated the remote microscopes at Parliament House.

Further work was done throughout the year to develop the CRC's presence on the ever changing social media scene. The use of Facebook increased – as did the number of people 'liking'our page – while the CEO's blog (talkingplantbiosecurity.com) and Linked-In remained in use.

To complement these social media channels we started using Twitter throughout the year with great success. We now have a number of people and organisations 'following' us, which is proving to be an excellent way to disseminate news and information. We also used Twitter during the Science Exchange, which generated discussions around the presentations. Each of these media channels is providing new and productive ways to disseminate information and raise awareness about biosecurity and the CRC's activities.

A positive sign for the CRC's social networking presence is the number of referrals the website is receiving from Facebook, with it continually ranked in the top 10 referring sites throughout the year.

The UAV hanging above the CRCNPB stand at the Innovation in Australia Showcase in Brisbane

Intellectual Property Management

Key pieces of IP held by the CRC and market value

As at June 30 2012, the CRC held the following key pieces of intellectual property (IP):

- Several copyrighted teaching resources and manuals
- A device to remotely monitor the levels of phosphine during fumigation of a sealed grain storage facility
- Copyright protected software to allow the collection of biosecurity surveillance data on hand-held devices
- A fumigation unit for sealed grain storages that incorporates a nitrogen generator, power supply and application subsystems
- A trademark protected PBT
- Software required to run a new diagnostic system based on 'OptoPlex Beads'.

The current market value of all of the above items is negligible as all require further development to create opportunities for commercial exploitation in what an external review found to be a limited market.

IP management arrangements

Our well established IP management processes continued to perform as expected during the 2011-12 financial year.

Our Canberra office has a responsibility to identify, secure, maintain and protect the new knowledge developed across our research portfolio. Pursuant to our governing documents, we define new knowledge to include both public domain and protected outputs and our IP register appropriately reflects this distinction. The IP register is situated within our online project management system, with access restricted to ensure confidentiality.

Very minimal project development occurred within the report period and as such, identification of new IP was limited. Nonetheless, due diligence in identifying new IP was carried out and all new projects continued to have the relevant IP and confidentiality stipulations built into their individual contracts. As a part of our ongoing efforts to continually reassess the IP status of our projects, research program leaders continued to provide quarterly updates as to any material changes in the IP status of the projects under their administration. As an additional level of IP oversight, the Board and its Finance and Audit Committee continue to receive quarterly reports updating the IP status of all our research projects and updated copies of our IP register.

Adherence to the National Principles of IP Management

Our *IP Manual* continues to be the cornerstone of our IP arrangements, providing policies and procedures for the classification of IP and, if appropriate, acquiring suitable protection on IP that has been deemed suitable for formal protection. The manual remains in compliance with the *National Principles of IP Management* and is administered by the Business Manager and Delivery and Adoption Officer.

As reported last year, external consultants were engaged to review the IP and enhance identification of commercial needs and value. During this reporting period, the CRCNPB evaluated the consultant's reports and the centre has decided to pursue a limited number of commercial opportunities in the grains industry during the next financial year. This will be carried over to the PBCRC in terms of responsibility (described in more detail on the next page).

Maximising benefits

Our IP arrangements ensure that our technologies will accrue maximum benefits to Australia by releasing material suitable for the public domain while keeping potential commercial successes confidential. As the development of our technologies continue to advance into the next iteration of the

CRC, arrangements for their commercialisation, technology transfer and accrual of national benefits will continue to develop commensurately and will focus on the specifics of the technology and associated market under consideration. This process may involve formal IP protection or technology transferral through mechanisms in the public domain as deemed appropriate by us and as guided by our IP policies and procedures. Irrespective of the pathway, these processes will follow the basic premise of assessing the cost versus the return to us, our participants and to Australia more generally.

Patents held by the CRC

The CRCNPB holds the following patents:

- Patent filed - New OptoPlex Beads Application, Software and Probes
- Patent filed USA – Descriptor of a Hyperspectral or Multispectral Image.

Individual IP arrangements have been established to manage these patents with third parties, with the CRCNPB maintaining oversight of the process to ensure suitable protection is acquired to facilitate future commercial opportunities.

Transitioning from CRCNPB to PBCRC

During the reporting period the CRCNPB was fortunate enough to be granted extension funding and from 1 July 2012, the PBCRC commenced operations. All IP contained within the current CRCNPB IP register will transfer to the PBCRC, including maintenance obligations of trademarks and patent applications. This will be conducted in a manner pursuant to the IP obligations outlined in the new Commonwealth Agreement. All CRCNPB participants have agreed to this arrangement and no objections were lodged from current CRCNPB participants not involved in the future PBCRC.

In the last quarter of the reporting period, IP management arrangements for the PBCRC were under development and will be in place as of the start of the new centre. They will build on the solid foundations the IP management regime in the CRCNPB has created. Additionally, an IP holding company has been established, PBIP, to help with the commercialisation and exploitation of PBCRC IP and will commence operations in tandem with the PBCRC. This will include the exploitation of commercial opportunities identified by external consultation (as detailed above) and any continual development of CRCNPB IP that makes its research outputs more attractive to the market.

Performance against Activities

Progress against the Key Challenge / Outcomes

The overall aim of the CRC as set out in the *Commonwealth Agreement* was to '*develop novel technologies, and to rapidly and efficiently transfer tools, knowledge and technology to end-users – agribusiness, producers, and the Australian and state governments – to pre-empt and diminish the economic and environmental impact of Emergency Plant Pests across Australia*'.

The *Commonwealth Agreement* also details seven outcomes, aligned to our programs, which contribute to our achieving the objective, namely:

- Outcome 1: Prevention – Reduced incidence of harmful plant pest incursions.
- Outcome 2: Identification – World class biosecurity capability for early identification of emergency plant pest and pathogens.
- Outcome 3: Detection – More effective national surveillance systems.
- Outcome 4: Response – Reduced losses from incursions of emergency plant pests.
- Outcome 5: Response – Post-harvest integrity: Cost effective insect pests control practices and future risk management aligned with market demands and industry.
- Outcome 6: Education and training – Increased awareness, knowledge and skills levels of industry personnel, and supply of trained scientists.
- Outcome 7: Commercialisation and utilisation.

A total of 21 *Commonwealth Agreement* milestones were due for completion in this reporting period, of which all but one has been achieved.

The table below provides details of the active and completed milestones as at 30 June 2012.

Program	Active milestones	Completed milestones
Preparedness and Prevention	0	10
Diagnostics	1	16
Surveillance	0	17
Impact Management	1	14
Post-Harvest Integrity	1	16
Education and Training	22	32
Delivery and Adoption	0	12
Cross Program	1	1
Consultancies	0	14
Total	**26**	**132**

Research

The past financial year has seen the completion of the CRCNPB research portfolio, delivering tangible outcomes to our end-users.

The commentary below demonstrates key research achievements for each program during the reporting period.

Program 1: Preparedness and Prevention Research

Program Leader Dr Rieks van Klinken

Several major projects were completed during this reporting period, resulting in completion of the final milestones and delivery against all three output areas.

The first output was knowledge to underpin decisions on risk of entry, establishment and spread of emergency plant pests (EPPs). Four major projects addressing this priority have been completed in the past year: two relating to risks of pests arriving into Australia through trade, and two relating to improving responses to new incursions.

Thousands of plant pests have the potential to arrive and establish in Australia, and it is important to know which are most likely to do so. As a first step, the 'world threat of invasive species' project combined the likelihood of organisms arriving (based on an analysis of trade) and likelihood of establishment (based on an analysis of where organisms come from). A similar approach was taken to better identify which ports and which ship arrivals pose the greatest risk to new incursions. Together this work is expected to result in further refinement of import risk assessments and inspection protocols, and this is being pursued with DAFF.

When new incursions do occur they can cause devastating impact. Rapid and effective responses to new incursions are therefore critical in minimising those impacts. Two projects therefore developed a spatial tool to help test pre-emptive surveillance and to estimate spread rates in real time. These incorporate biological parameters of the pests, and environmental data, and can be updated with surveillance data as it becomes available. One approach was developed for fruit-flies, fireblight and gypsy moth within a generic software application framework. The second project developed a similar approach, a 'General Model of Biological Invasion' that seeks to more quickly characterise and simulate a new EPP. It aims to be sufficiently abstract to capture a wide range of different types of organisms, and thereby be readily adapted to new pests as they arrive. This framework was successfully tested against three organisms, an insect, a fungal pathogen and a weed. Both approaches provide decision-makers with spatial decision support tools to improve responses to plant pest outbreaks.

The second output was new risk assessment, economic and complex system models for biosecurity. A large, ambitious project delivered against this priority in the past year. This project developed and tested an approach to refine invasion response plans to EPPs by combining bioeconomics, map-based predictive incursion maps, non-spatial statistical modelling, and structured decision making techniques. These assessments were trialled with the Apple and Pear Australia Ltd. and the Australian Banana Grower's Council. This included using interactive 'war-gaming' of fire-blight incursions in the Goulburn Valley, Victoria to help decision-making groups evaluate different incursion response options. The approach was found to be of great strategic significance in setting broad research agendas and funding priorities.

Future climate change is expected to influence pests and diseases and the biosecurity risks that they pose.

A second project therefore developed predictive modelling tools to help decision-makers better anticipate the plant biosecurity consequences of climate change. This approach was demonstrated using the aphid-yellow dwarf virus system in wheat. This modelling work was complemented with empirical studies under elevated CO_2 using wheat pathogens and an aphid which demonstrated some of the diverse effects that can be expected under realistic CO_2 and climate change projections. Together this work increased understanding of the role of rising CO_2 and its influence on wheat pests and diseases.

The final output was more efficient and effective responses to EPP through better understanding of their biology and epidemiology. This was addressed through case-studies in all of the projects described above. It includes generating detailed impact assessments for five key plant pathogens of bananas, with direct implications for managing these risks into the future, and simulations of likely future incursions of a wide range of plant pests and diseases. Field testing of models is critical for the uptake (Milestone 1.2.5, June 2012). This is not always possible or feasible, especially for pests that are not yet in the country. However, this was achieved for incursion response simulation modelling using organisms that are already in the country, including fruit flies and herbivores that were intentionally released as biological control agents.

Overall the completion of these projects adds to Australia's ability to strengthen its abilities to address likelihood of entry and consequence and our ability to improve our capacity to better allocate resources in terms of biosecurity prioritisation. This body of work helps deliver towards the risk-return approach identified in the Beale Review.

The body of research produced by Program 1 is primarily aimed at the science/policy interface and is increasingly being used with DAFF, the principal end-user of this research. Additionally, PHA is using the various threat identification and prioritisation tools developed through the program.

Program 2: Diagnostics Research

Program Leader Dr Deborah Hailstones

Research in this program has completed a series of projects that delivers on building a world-class biosecurity capability through new data, expertise and technology and that is based on accurate, sensitive, reliable and cost-effective diagnostics. All projects have been completed on time and within budget, and have delivered positive results in terms of both scientific knowledge and building human capacity.

A series of projects focused on developing novel digital tools for the plant biosecurity community, improving the sharing and optimization of diagnostic information. In particular, the new version of the Pest and Disease Image Library (PaDIL) delivered increased functionality and better integration to all products in this range, providing greater flexibility to the user to create and customise their own image libraries and to personalize their PaDIL usage via their own Dashboard. The Dashboard is central to the Remote Microscopes portal, which offers an identification enquiry system that can manage, track, store, report and search laboratory information. The RMN has more than fifty locations within Australia and internationally and also serves as a novel system to provide training to remote locations. Portability of the network is provided through hand-held Dino-lite cameras to provide images to the microscopes for identification. These projects won the CRC Association Award, *The Australian* newspaper Innovation Award for Agriculture and the Queensland

Premiers Award, confirming the importance and relevance of digital technologies and innovations in shaping the future and conceiving new paradigms.

A suite of completed projects made outstanding progress against the key science outcome of new protocols for rapid identification of pests and diseases that threaten plant industries. A significant biosecurity quandary is providing robust and rapid identification to the exacting level required. One project demonstrated the effectiveness of proteomics and metabolomics, approaches that identify functional molecules, to discover novel biomarkers to differentiate closely related bacterial pathovars. The project identified and validated new diagnostic techniques that differentiate organisms to the level of specificity required but where diagnostic tests were not previously available. These will be incorporated into the National Diagnostic Protocol (NDP) and will translate to improved incursion response because their greater specificity and reliability reduce turnaround time for testing. Extensive data has been generated that is yet to be mined, but is likely to deliver further tests in future. Significant specialist capacity in bacteriology has been fostered both nationally and internationally, through recruitment and professional development, which will benefit Australia's plant industries through local expertise and trusted 'off-shore intelligence'.

Another project completed in 2012 sought to identify insect-derived olfactory receptors that could potentially be used as biological detectors, or sensors, of insects in stored grains. These could perform real time detection and identification of a wide range of volatile chemicals, providing a cheap, robust and constantly available detection technology. The project identified four volatiles that are associated with the presence of beetles and so would be appropriate targets for detection of insects in stored grains. Candidate olfactory receptors that could later be developed into sensors for a biosensor device have been thoroughly examined. A candidate pair of a receptor and the signal (ligand) that binds to it was identified and whilst it was not possible to demonstrate their functionality using the model system used, alternative models may allow comprehensive characterisation in future. The next phase of this research could draw on these results to develop a transduction platform to carry the signal from an insect receptor to an electronic device or implement the Cybernose® capability currently being used for prototype biosensors, to demonstrate detection of insects in stored grains.

These projects will deliver tools that improve responsiveness to plant biosecurity incursion events.

In many cases, the issue of developing diagnostics is complicated by uncertainties in the taxonomy, or naming, of the pests, and these issues must be unravelled first. A classic case is the *Bactrocera dorsalis* complex of fruit flies, which contains four taxonomically defined 'species' that are internationally recognised as important pests of tropical fruits and vegetables. There are no consistent diagnostic markers for these species, so one completed project used an integrative taxonomy approach to identify the species limits of the four sibling pest species. The project combined behavioural, genetic and morphological tools to conclude that *B. dorsalis*, *B. papayae* and *B. philippinensis* constitute one biological species, and *B. carambolae* a second. Molecular markers were identified which separate these two groups for diagnostic purposes. A smaller, supplementary project analysed microsatellite repeats in flies from a key area of geographic overlap between these two taxa and provided additional data for the combining of *B. dorsalis* and *B. papayae*. The recommended combining of *B. dorsalis*, *B. papayae* and *B. philippinensis* will have significant implications for trade and market access in the south-east Asian and Australian regions. It will simplify the development of Pest Risk Analyses because very significant information exists for *B. dorsalis*, but substantially less for *B. papayae* and *B. philippinensis*. Quarantine is enhanced through easier surveillance (focus on one species, not three) and improved diagnostics.

Another completed project ensures early identification of a particular plant biosecurity threat, Khapra beetle, by ensuring its robust differentiation from many local (but non-invasive) species. The project captured accurate and reliable surveillance

data on local populations and developed expertise, images and technologies to differentiate the species. These activities have resulted in the development of the *Trogoderma* and Related Dermestids Identification Service, or TARDIS. This service is fully operational, providing diagnostic services that are supported by a Diagnostic Imaging laboratory and a Molecular Diagnostics Laboratory. TARDIS and its supporting labs offer a platform for ongoing surveillance and management of Dermestid beetles and provide baseline data on the local Dermestid fauna associated with grain-handling facilities and evidence of pest free status from Khapra beetle. The project has also included ongoing taxonomic analysis and imaging of key species and the development and validation of new molecular protocols. Another key development is the building of linkages to the PaDIL database via digital microscope imaging of morphological characters, building a library of images. Images and data for this have now been incorporated into another CRC project: *Trogoderma* training (CRC60185).

Program 3: Surveillance Research

Research Leader Dr David Eagling

In the final year of the program, surveillance development was managed with a strategic objective to 'undertake research that will develop technically sound sample/survey methodologies and systems that enhance the ability to capture a wide range of plant health information in an accurate and cost-effective manner both domestically and internationally'.

A key achievement has been the development of a flexible and statistically robust system for grain sampling.

As grain loading processes have increased over time it has become impractical and dangerous to draw samples manually. A number of new methods have been developed to draw samples to both increase safety and reliability of sample procedures. Automated sampling and sieving mechanisms have been developed and incorporated into shipping ports. The sampling rate of 2.25 litres / 33 tonnes has been maintained and remains the export standard today.

The project has made strong basic advances in the sampling theory of stored grains by accounting for the ecology of stored insect pests and allowing for increased sampling efficiency. The advances are essentially theoretical and have been well published.

Another key achievement has been through supporting a national Grains Farm Biosecurity Program (GFBP) which was initiated by the Australian grains industry in response to an industry need to prepare for and respond to biosecurity threats and incursions.

The GFBP includes Grains Biosecurity Officer positions which operate in the five major grain states (WA, Qld, Vic, SA and NSW). The Officers have undergone a structured training program and in undertaking standardised surveillance activities have developed networks that provide information and demonstrate biosecurity practice change to the grains industry through:

- Identification of target audiences and stakeholders – who they are, their current knowledge and perceptions of biosecurity
- Identification of the knowledge and information that stakeholders require to demonstrate current biosecurity practices
- Identification of 'trusted sources' of information and development of long term relationships between these sources and stakeholders
- Defining effective methods of communication to produce relevant messages that address the risks and issues of the stakeholders.

In horticulture a key achievement was the development of ways to reduce costs of fruit fly surveillance while maintaining high monitoring efficiency.

A new method termed 'dynamic trapping' was demonstrated to be more effective in the capture of Mediterranean fruit fly (*C. capitata*) than the existing static trapping method.

The dynamic method detected fruit fly infestations earlier than the static method (with low fly numbers) and required one-third to one-half the number of traps used in a static grid to obtain the equivalent information on detecting itinerant or established fly numbers required for the fruit fly code of practice. This result was consistent over three seasons where population level was quite different in each season.

In WA trials with very low fly density there was no difference in fly detection between the static and dynamic trapping methods.

Queensland fruit fly (*Bactrocera tryoni*) results were variable and inconclusive in three trials which had low-high fly densities.

The work found that in areas of low fly density strategic placement of traps in fruiting hosts increased the chance of detection of flies and the likelihood of capturing flies earlier. The greater effectiveness of this trapping method would reduce costs and benefit the industry in terms of minimising the number of undetected incursions leading to outbreaks and loss of market access in affected areas.

The methods developed were able to prove area freedom and also proved effective in areas of low pest prevalence (ALPP). It is therefore useful to extend dynamic trapping methods as suitable for consideration in proving ALPP in the further development of the fruit fly codes of practice for market access. Since fewer numbers of traps are required to prove ALPP the costs of such a trapping regime may be affordable for growers.

Program 4: Impact Management Research

Program Leader Ms Jane Moran

At the end of the CRCNPB, all Commonwealth Milestones for Program 4 have been achieved.

CRC fruit fly research has begun to deliver on the National Fruit Fly Strategy, especially in relation to Strategy 9.2: 'improving the understanding of the application of field-control measures in relation to fruit fly ecology, crop architecture, landscape ecology and integration with management strategies for other pests'. Some unexpected findings include the roosting of flies in remnant native vegetation, and flies foraging high in the canopy. These very complex studies on fruit fly ecology have resulted in some practical improvements to our current fruit fly control measures during outbreaks in our pest free zones. In endemic areas researchers have found that crop architecture significantly influences fly behaviour and this has implications for the spatial application of controls.

Data mining and analysis of comprehensive field based studies conducted in the 1960s has revealed new knowledge of the seasonal abundance of fruit flies. This knowledge may open new opportunities for market access and improved control strategies.

New 'Integrated Insect Eradication (IIE)' approaches for controlling pest incursions into agricultural, peri-urban and urban areas show great promise. Studies on the Tortricid light brown apple moth (a model study species for the exotic Tortricids such as Asian Gypsy moth) has shown the efficacy of

SPLAT™ (Specialised Pheromone and Lure Application Technology). In an urban environment SPLAT™ achieved greater than 90% mating disruption for more than 90 days, this was more than twice the effective time expected.

A New Zealand database that compiles worldwide data on incursions and eradication responses was expanded to include all published and unpublished data from Australia. This resource will be mined for knowledge to improve decision making for future incursions.

Program 5: Post-Harvest Integrity Research

Program Leader Dr Pat Collins

2011-12 was the final year of this five-year supplementary Program. The mission of the Post-Harvest Integrity Research Program was to deliver scientific outputs that will contribute significantly to the effective management of biosecurity threats in the post-harvest grain sector and support sustained market access for Australian products. The most urgent issue for the grain industry is the development of strong resistance to phosphine fumigant in insect pests. This resistance seriously threatens access to both domestic and international markets for Australia's grain crop valued at about $13 billion.

The Program's short-term priority has been to control resistance outbreaks in key pests. Although based on chemical tactics, the success of this work has provided the opportunity to investigate and develop longer term, sustainable pest and resistance management strategies. A key feature of our work has been the participation of end-users in every project commissioned. Any solution, whether short or long term, must be cost effective and comply with market preferences for insect and residue free products and a range of regulatory requirements.

The Program has delivered research supporting achievement of a suite of contracted CRCNPB Outputs due in 2011-12.

Three Outputs, 1.4, 2.5 and 5.1, refer to the development of strategies for containment of resistance through the supply chain and this has been a priority of Program 5. Resistance development is obviously an outcome of humans applying a very severe selective agent against an insect population. However, if and how rapidly this process occurs depends on the genetic and ecological characteristics of the target species. Any strategy aimed at containing, that is, delaying or combating the development of resistance in a sustainable way, must be informed by an understanding of the movement of these insects in the landscape. CRCNPB research has revealed for the first time that these insects disperse through flight broadly in the landscape, overturning the accepted international view that they tend to remain within the storage. The research found that flight dispersal continues for many months of the year.

In addition, molecular studies showed that as a consequence there was a high level of genetic and demographic connectedness across the landscape. It was also established that any differences in walking or flight initiation behaviour between resistant and susceptible insects was minimal, indicating that resistance genes are dispersed broadly from the point of selection as readily as wild type genes.

Surveys of the frequency, distribution and strength of resistance to phosphine indicate that strong resistance development is being successfully contained. The most severe resistance incidences were caused by rusty grain beetle in eastern Australia; however, control failures due to these insects were halved in the last two years due to application of CRC-researched management tactics. The monitoring program also continued to provide early warning of resistance developments, for example, effective action was taken in Western Australia to eradicate incidences of strong resistance detected there. The

national Phosphine Resistance Management Strategy developed by CRCNPB researchers in collaboration with industry can be accessed at: http://www.graintrade.org.au/chemical_tolerances

Program 5 also contributed significantly to a second group of Outputs that specify the development of new and improved technologies for the treatment (disinfestation) of biosecurity risks and management of resistance (Outputs 2.6, 3.2, 4.3, 5.2, 7.5.1). As previously mentioned, Program 5 scientists developed highly successful protocols for the control of outbreaks of phosphine resistance in rusty grain beetle. This work also provided the grain industry with protocols for use of an alternative fumigant that will help to reduce selection pressure on phosphine. In addition, the development of an economically feasible low oxygen fumigation technology provided the industry with a completely chemical-free treatment.

Grain storages cannot take advantage of these new gaseous treatments unless they are sufficiently gas-tight and in most cases this requires modification of structural elements of the storage as well as an understanding of how best to deploy gases through the grain bulks. Two projects that were completed at the end of 2011 provided a range of industry-based protocols and methodologies to improve fumigation treatments and understand the fumigation process.

A different treatment approach is to reduce the temperature of grain by introducing cool dry air into the silo (aeration). This treatment results in greatly reduced insect population growth within the bulk. Aeration cooling is a physical treatment that is a particularly important and useful technology for farmers. However, until now, there was no way for farmers to measure whether the air flow rates within their silos were sufficient for the purpose. CRCNPB researchers have developed a practical methodology that farmers can use themselves to measure airflow rate to greatly improve the efficacy of this treatment.

Projects developed and managed in Program 5 made important contributions to two other key Outputs: Output 3.1: Surveillance procedures linked to information databases etc. to capture data required to define plant health status, and Output 7.3.1: New generation of world class and cost-effective surveillance tools and methodologies for key plant pest threats of national importance.

The Australian Grain Insect Resistance Database is the repository of many thousands of records associated with the national resistance surveillance program, collected over many years. However, the information this data warehouse contains is difficult to access and interrogate. A pilot project successfully developed a statistical methodology using a hurdle model with Bayesian classification trees and generalised linear models to analyse a portion of the database and gained preliminary insights into resistance development. The project demonstrated that it is now feasible to analyse the whole database.

In another investment, the feasibility of developing a molecular diagnostic for phosphine resistance to replace the limited and lengthy conventional bioassays was investigated. Although gene-specific diagnostic markers were developed for strong resistance in two major pest species, it was found that resistance expressed by this gene is based on several mutations occurring independently in insect populations. This means that the opportunity to develop a single molecular diagnostic test for all phosphine resistance is limited. However, tests for known mutations can be used for regional surveillance and provide extremely valuable research tools for understanding the ecology and evolution of resistance. Further investigation also demonstrated that gene expression profiling was not a suitable basis for developing a test.

Identification of the phosphine resistance genes, however, is beginning to yield exciting possibilities. Gene function analyses determined that the strong resistance gene is similar in the two species and is a basic metabolic gene integral to the Krebs cycle (or tricarboxylic acid cycle). Further research revealed that this gene also causes hypersensitivity to arsenical chemicals suggesting the pathway to development of potent synergists for phosphine. Complementation studies have shown that resistance genes occurring overseas are the same as occur in Australian insects. The international significance of these findings is demonstrated by its acceptance for publication by the highly prestigious academic journal Science.

Utilisation and Commercialisation

The financial year saw a significant amount of delivery and adoption across the CRCNPB research portfolio. A considerable number of utilisation and commercialisation outputs fell due during the reporting period given it is was the final contracted year of the CRCNPB. As such, the following reports on each provide evidence of completion and where appropriate, examples of uptake. It also lists the *Commonwealth Agreement* utilisation and commercialisation milestones to which each output relates. In all cases, the milestones were successfully met as the subordinate outputs were fully completed by our project activities (in some cases in previous years when the relevant output was due – these have not been included in this report).

1.1 New models utilised to combine comparative risk analysis and risk assessment to predict threats

As all subordinate milestones were achieved, this output was achieved on time.

1.1.3 New models of risk prediction delivered to agencies for use on selected emergency plant pests

The CRCNPB over its seven years of operation invested considerable resources into developing models for risk prediction. During the reporting period a number of these models were utilised by agencies in dealing with emergency plant pests. For example, CRC10162 developed a decision-support model based on risk assessment and expert elicitation. The project team delivered the model to biosecurity agencies at a workshop showcasing the map-based pest incursion management tool using the example of a fire blight outbreak in apple and pear orchards in the Goulburn Valley, Victoria. The model uses large touch screens to show an agricultural region potentially affected by a pest, and plots the location of susceptible plants. A user can then start an outbreak by touching one of the susceptible areas on the screen, and then watch as the incursion spreads over time. They can then initiate response policies to see how to best manage the outbreak. The Melbourne workshop was attended by 24 people from across the Victorian apple and pear industry, state and federal government biosecurity managers and scientists.

2.1 Comprehensive, world class diagnostics for emergency plant pests available through national and international databases

As all subordinate milestones were achieved, this output was achieved on time.

2.1.3 Comprehensive diagnostic data sets for emergency pests and pathogens submitted to accessible, national and international databases

The CRCNPB has not only developed new and improved diagnostic data sets; it has established an internationally recognised database in which to host them. CRC27012 developed the PBT, an online national diagnostic database that contains a collection of diagnostic protocols and provides users with images, taxonomic and biological information and data sets as well as identification instructions, diagnostic procedures and contact details for experts and accredited diagnostic laboratories. The PBT is hosted by Museum Victoria's PaDIL database and it is the first dedicated resource in Australia that takes diagnostic data off laboratory shelves and puts it into a forum that is usable, accessible and invaluable to plant diagnosticians. In 2010 alone, the PBT and PaDIL were accessed by over one million visitors from 190 countries, accessing over 13 million pages. The PBT along with its sister project in remote microscopy have received a number of awards including *The Australian* newspaper Innovation Award for Agriculture, the CRC Association Award for Excellence in Innovation and the Queensland Premier's Award.

2.2 Delivery of diagnostic tests to end users

As all subordinate milestones were achieved, this output was achieved on time.

2.2.3 Production of lab manual and training of relevant staff

The CRCNPB developed an enhanced protocol for Karnal bunt using a one tube fluorescent polymerase chain reaction (PCR) assay for the simultaneous detection and unequivocal identification of *T. indica* and closely related *Tilletia spp*. The enhanced protocol bypasses the germination step in identification, lowering the number of days elapsing before

definitive confirmation. This is critical in an incursion when huge quantities of wheat grain are being held at ports for export pending an outcome of diagnosis. The savings in cost and time stemming from the enhanced protocol make it a low cost and robust tool to detect the pathogen and help declare freedom from the disease for market access. The enhanced protocol has been laboratory verified and peer reviewed by the Subcommittee on Plant Health Diagnostic Standards (SPHDS) and will be submitted to Plant Health Committee (PHC) in 2012 for final endorsement and distribution to laboratories.

In terms of training diagnosticians, the CRCNPB has long recognised the need to protect our borders from exotic pests and disease and as such, conducted a series of training workshops in conjunction with ACERA with Thai scientists in molecular diagnostics. Workshops in both Australia and Thailand were focused on learning diagnostic techniques for a range of pests (that have particular biosecurity importance for Australia and Thailand) such as citrus canker, potato viruses and fruit flies, recognising the role of international collaboration in protecting our enviable plant health status.

3.1 A new generation of world class and cost effective surveillance tools and methodologies developed for emergency plant pests of national importance

As all subordinate milestones were achieved, this output was achieved on time.

3.1.5 Cost-effective surveillance protocols for emergency plant pests of national importance accepted by major trading partners

The CRCNPB recognises the importance of cost-effective surveillance in combating emergency plant pests. As such, the CRCNPB has developed a dynamic trapping method that strategically targets fruit flies by deploying traps in hosts at the time when they are most attractive to fruit flies. This is aimed at gaining greater efficiency in early detection of incursive populations. More effective and earlier detection will minimise the number of undetected incursions which lead to breeding populations, thereby reducing eradication costs and more effectively managing area freedom for market access.

The deployment of dynamic trapping has shown to provide an equivalent proof of area freedom at lower costs compared to the deployment of static trapping grids as outlined within the *Code of Practice for the Management of Queensland Fruit Fly*. The research found that the number of traps deployed can be reduced by 50 per cent where suitable hosts are available. The research validates the effectiveness of strategic trap placement and gives regulators the confidence to approve lower-cost systems for areas of low pest prevalence, and to provide evidence of area freedom.

This recommendation was compiled into a manual on Fruit Fly Traps and their Placement (refer table below) and forwarded to the Domestic Quarantine and Market Access Working Group (DQMAWG) for their consideration.

4.1 Tools to underpin surveillance and response delivery

As all subordinate milestones were achieved, this output was achieved on time.

4.1.3 Tools and models implemented and incorporated in operational processes of industry and government

A number of tools developed by the CRCNPB have been incorporated into the operational processes of our end users. For example, CRC40050 successfully developed, validated and completed a novel pair of group-specific universal primers for detection of virus species within the Potyvirus genus. This test is a unique approach and can be applied to other genus. This superior diagnostic tool has led to seven protocols being submitted to SPHDS for validation and approval by PHC. In addition, they are in regular use by DPI Victoria on behalf of AQIS for the screening of imported plant products.

Furthermore, CRC40016/40139 has developed an innovative approach to pathogen eradication in grape vines that has been included within the PHA *Biosecurity Plan*. This approach provides an alternative eradication protocol that only removes and destroys part of the host plant, thus enabling faster regeneration and minimising the social and economic impacts often caused through the destruction of the entire host plant. This approach may have enormous potential for horticultural industries where pathogen eradication involves the removal and destruction of entire crops and orchards.

5.1 New technologies to manage resistance

As all subordinate milestones were achieved, this output was achieved on time.

5.2 National Grains Extension Strategy: better practices for future risk management in industry

As all subordinate milestones were achieved, this output was achieved on time.

5.2.2 Incursion response plan based on quantitative knowledge of the dynamics of the grain supply chain

The CRCNPB has developed a National Grains Surveillance Plan to coordinate surveillance activities for the collection of data to support claims of area freedom and to ensure early detection in the case of an incursion. The plan outlines protocols and procedures for exotic pests and is supported by a series of specific surveillance plans for individual pest species based on factors such as a host, pest biology and epidemiology, potential impact to the industry, pathway assessment and complexity of pest or disease symptoms and diagnosis.

5.2.3 Implementation of a national phosphine resistance containment strategy

The CRCNPB established the National Resistance Monitoring Program (NRMP) that has contributed significantly to phosphine resistance management by providing industry with both strategic and tactical information on the frequency, distribution and strength of resistance. Previous resistance monitoring was undertaken independently in the three grain regions of Australia and this project succeeded in combining these three systems into one, allowing the regions to be compared and national trends to be identified.

The NRMP was instrumental in the detection of very highly phosphine resistant populations of the Flat Grain Beetle (FGB). This discovery led to the establishment of a related CRCNPB project that developed a new fumigation protocol and an eradication strategy for the FGB. A quick test was developed to provide bulk handlers with a tool to easily and quickly determine whether there is high resistance within a FGB population and to identify the appropriate management response. These strategies were developed for industry to improve the timeliness of both detection and response to resistant insect populations.

The FGB protocol has since been implemented at all Graincorp southern and northern sites (where FGB have been found). A sample from Graincorp's Moree site provides evidence that the level of resistance within the FGB populations has been reduced. This reduction can be attributed to the practices Graincorp have implemented as a result of the research findings.

6.1 Effective communication and delivery strategy operational

As all subordinate milestones were achieved, this output was achieved on time.

In order to meet this milestone, a number of information resources were created across the programs to help in the delivery of research outputs, such as:

- Species data sheets (Program 1)
- Laboratory manuals (Program 2)
- PDA software user guides (Program 3)
- Decision matrix for eradication response (Program 4)
- Phosphine resistance management strategy (Program 5)
- Post-graduate plant biosecurity course material (Program 6)
- Economic assessment tools for stored grain silos (Program 7)

Overall Completion

The completion of the milestones and outputs described above, coupled with the completion of all other outputs and milestones from previous reporting periods, signifies the successful completion of the commercialisation and utilisation obligations of the CRCNPB as outlined in the *Commonwealth Agreement*. This represents a collaborative effort between CRCNPB staff, researchers and end users in helping to support Australia's biosecurity efforts through a shared commitment to implement scientific best practice.

Education and Training

Program Leader Dr Kirsty Bayliss

One of the key aims of the CRCNPB was to improve Australia's future capacity in plant biosecurity by enhancing the quality and quantity of education and training available to industry, undergraduate and postgraduate students. Further, we wanted to raise awareness of biosecurity issues at the industry, community, and secondary and primary school levels. We committed to support up to 32 PhD students and to provide training for scientists and others working in plant biosecurity to enhance the core capacity of Australia.

As at 30 June 2012, all of our milestones are either completed, or on target to be met before December 2012. The CRC recruited more than 40 researchers at PhD level, with 16 submitted for examination by the end of June 2012. Furthermore, we trained 10 honours students. All of our students have received supervision from staff from our university and industry participants. Graduate destinations include many of the CRC participants including DAFWA, QDAFF, and DAFF Biosecurity, in addition to overseas postdoctoral placements. When combined with students in our postgraduate Plant Biosecurity courses and our yearly professional development workshops, the CRCNPB can claim credit for training more than 70 new researchers in plant biosecurity, and this does not include our postdoctoral fellows.

In addition more than 200 schools across Australia have taken part in our pre-primary, primary and secondary school activities. Further, we have continued to deliver workshops to deploy outcomes from our research projects to end-users, with on-going training in remote diagnostics, and the development of new online modules in pest diagnostics. The CRC participants and end-users have been closely involved with the development, delivery and review of our education and training activities, to ensure that all activities will provide a lasting research capability and awareness of plant biosecurity across Australia.

The impact of our capacity building activities was demonstrated in the response to the myrtle rust incursion in New South Wales. Our PhD students in particular were closely involved in trapping spores of the rust fungus for detection and surveillance, modelling dispersal of the spores, and, with international collaborators, predicted movement of the fungus using the NASA Terrestrial Observation Prediction System. One of our completed PhDs is also now working on the epidemiology of the disease in a position specially created to tackle the problem. None of this would have been possible without the training provided by the CRC.

The CRCNPB has played a critical role in the establishment of three new postgraduate coursework degrees in plant biosecurity. They include a Certificate, Diploma and Masters of Plant Biosecurity. These courses are the first in the world to be delivered in this field and are aimed at staff working in biosecurity who wish to gain further qualifications specific to their occupation, as well as people who wish to begin a career in this field. At a May 2012 Senate Committee hearing it was noted by DAFF Biosecurity Deputy Secretary Rona Mellor that the Department is developing a policy so that their staff enrol in the course. We have more than 40 students enrolled and the courses are seen as a legacy that will last well into the future, beyond the life of the CRCNPB.

"The CRCNPB has played a critical role in the establishment of three new postgraduate coursework degrees in plant biosecurity."

SME Engagement

The CRC's SMEs are the more than 50,000 farmers involved in plant industries. These SMEs are represented and engaged through their industry R&D organisations, GRDC, HAL and PHA, who are participants in the CRC. In addition, the CRC works closely with other organisations, such as Grains Producers Australia and the National Farmers Federation, who represent farmers and agribusinesses.

The list of CRC research projects contains many projects involving our SMEs. For example, we have an eradication project which has been examining black rot disease in grapes and which has been doing trials with vineyards in the Sunraysia region, near Mildura, Victoria. Similarly, we have been conducted trials with grains farmers in Queensland on cool grain fumigation.

We regularly exhibit at industry conferences and congresses. For example, in 2010-11, we had exhibition booths at the Australian Grains Industry Congress and Banana Growers Congress. This allows us to speak directly to growers and agribusinesses and inform them of the work being undertaken by the CRC. We also provided 450 copies of the corporate magazine, *Plant Biosecurity collaborative research initiatives* as bag inserts for the AusVeg National Conference.

Collaboration

The year witnessed further growth and development of the CRC's network of remote microscopes.

Remote Microscopy connects insect and plant pest and disease specimens with experts in real time via a web based feed, allowing immediate, interactive and accurate identification of specimens.

The network has a nominal headquarters in the Australian National Insect Collection (ANIC) which is located in Canberra, Australia and during the year the network expanded to 44 locations across Australia, New Zealand, Thailand, Vietnam, Singapore and East Timor. The network operates as a community with a high level of collaboration and participation within the growing network community.

The mutual benefits in skill acquisition and expert utilisation gained through the network provide a tangible example of our efforts to develop a national network for biosecurity science with linkage to international efforts and expertise.

We continued collaborative efforts through the quadrilateral scientific collaboration in plant biosecurity (QUADS-SciCo) alliance. In working with biosecurity colleagues in Canada, New Zealand and the United States of America, key areas of development and interest during the reporting period were risks posed to biosecurity by climate change and new surveillance technologies.

Ongoing development of collaborative links with Indigenous communities in northern Australia and eastern Indonesia resulted in implementation of a community biosecurity model at the political system level, industry system level and education and training system level.

During the reporting period it was pleasing to witness national policy in Indonesia adopting the term 'biosecurity'. A number of senior Ministries worked on implementation activities which were highlighted by the Maluku Province of Indonesia apportioning a budget to roll out biosecurity measures in partnership with the CRCNPB.

In Australia, the biosecurity model and associated resources were adopted by a number of Indigenous communities and the Northern Australian Indigenous Land and Sea Management Alliance to develop their strategy for a surveillance data collection program. The model was also used by the Northern Territory Government's Department of Natural Resources, Environment, The Arts and Sport to negotiate and improve community engagement in plant biosecurity and other related work.

At a commercial level, we also continued to provide successful consultancy services to Chevron Australia Pty Ltd. This commercial collaboration continues to assist Chevron in meeting the environmental operational requirements of the Gorgon project off Western Australia's northern coastline. These activities fell within the Activities specified in the *Commonwealth Agreement*.

Other Activities

During the 2011-12 financial year, all activities undertaken by the CRCNPB fell within the Activities specified in the *Commonwealth Agreement*.

Additional Requirements

Third Year Review

All recommendations from the *Third Year Review* were reported as completed in the *Annual Report 2009-10*.

Extension CRC

In November 2011 the CRC NPB Ltd, recipient of the 2005 grant for the CRCNPB, was successful in its bid for funding the PBCRC until June 2018.

The PBCRC's mission is to develop and deploy scientific knowledge, tools, resources and capacity to safeguard Australia, its plant industries and regional communities from the economic, environmental and social consequences of damaging invasive plant pests and diseases. To achieve this mission the outcomes and outputs of the CRCNPB were considered appropriate to roll over into the PBCRC.

To achieve this, the CRC NPB Ltd has done a number of things:

- Changed its name to PB CRC Ltd
- Formed a subsidiary company, PB IP Ltd to fully own and manage all intellectual property (IP) developed by the CRCNPB and any developed in the operation of the PBCRC
- Executed a Termination Deed to:
  - transfer full ownership of IP to the PB IP Ltd and
  - allow all other assets held by the Company at 30 June 2012 to be kept by the Company to help resource the operations of the PBCRC.

Only one Core Participant in the CRCNPB did not become a Participant in the PBCRC. This Participant having a very small stake in any IP agreed to transfer all ownership rights to the PB IP Ltd.

As at 30 June 2012 the account held a balance of $3.8 million which included funds needed to pay CRCNPB liabilities. The PB CRC Ltd has sought to transfer $2,030,068 from the CRCNPB account to the PBCRC account recognising that a large portion of these funds are the contributions from the CRCNPB's Participants.

Since 30 June 2012 funds have been spent on CRCNPB project milestones, new PBCRC project milestones and administrative costs including set up costs such as legal fees.

Glossary of Terms

ACRONYM	MEANING
AGM	Annual General Meeting
ACERA	Australian Centre of Excellence for Risk Analysis
ALPP	areas of low pest prevalence
AQIS	Australian Quarantine and Inspection Service
CABI	CABI - was formerly called Centre for Agricultural Bioscience International
CEO	Chief Executive Officer
CRC	Cooperative Research Centre
CRCNPB	Cooperative Research Centre for National Plant Biosecurity
CRC NPB Ltd	Cooperative Research Centre for National Plant Biosecurity Limited (The Company)
CSIRO	Commonwealth Scientific and Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
DAFWA	Department of Agriculture and Food, Western Australia
DEEDI	Department of Employment, Economic Development and Innovation
DIISRTE	Department of Industry, Innovation, Science, Research and Tertiary Education
DPI	Department of Primary Industries
EPP	Emergency Plant Pest
FGB	Flat Grain Beetle
GFBP	Grains Farm Biosecurity Program
GRDC	Grains Research and Development Corporation
HAL	Horticulture Australia Limited
IIE	Integrated Insect Eradication
IP	Intellectual property
MOU	Memoranda of Understanding
NRMP	National Resistance Monitoring Program
NZ	New Zealand
PaDIL	Pest and Disease Image Library
PDA	personal digital assistant
PBCRC	Plant Biosecurity Cooperative Research Centre
PBT	Plant Biosecurity Toolbox™
PHA	Plant Health Australia Ltd
PHC	Plant Health Committee
PhD	Doctor of Philosophy
PIRSA	Department of Primary Industries and Research South Australia
QDAFF	Queensland Department of Agriculture, Fisheries and Forestry
QUADS	Quadrilateral Agreement on Plant Health

ACRONYM	MEANING
QUT	Queensland University of Technology
R&D	research and development
RMN	Remote Microscope Network
SME	small to medium-sized enterprise
SPHDS	Subcommittee on Plant Health Diagnostic Standards
SARDI	South Australian Research and Development Institute
SPLAT™	Specialised Pheromone and Lure Application Technology
TARDIS	Trogoderma and Related Dermestids Indentification Service
UAV	unmanned aerial vehicle
USA	United States of America

Publications

Books

Falk, I., Wallace, R. and Ndoen, M.L. (2011), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, 302 pp.

Book chapters

Falk, I. and Wallace, R. (2011), 'Managing Plant Biosecurity Across Borders', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 3–19.

Falk, I., Wallace, R., Ndoen, M.L., Surata, S.P.K., Royce, P., Mudita, I.W., Martiningsih, E., Litaay, T., Mampouw, H.L., Jayantini, S. and Natonis, R.L. (2011), 'A strategy for managing biosecurity across borders', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 215–236.

Jayantini, S.R. (2011), 'Knowledge Transfer Through Bilingual Publications on Food Security and Biosecurity', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 145–161.

Litaay, T. (2011), 'Adoption of Local Knowledge in Regional Biosecurity Development: Papua Case Study', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 45–63.

Litaay, T. (2011), 'Policy and Legal Framework for Managing Biosecurity', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 23–43.

Low-Choy, S., Murray, J., James, A. and Mengersen, K. (2012), 'Elicitator: a user-friendly, interactive tool to support elicitation of expert knowledge', in Ajith, H., Perera, C., Drew, A. and Johnson, C.J. (eds.), *Expert Knowledge and its application in Landscape Ecology*, Springer, New York, pp. 39–67.

Martiningsih, E. (2011), 'Gender Issues in the Community Management of Biosecurity in Eastern Indonesia', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 163–181.

Mudita, I.W. (2011), 'Crossing the Community-Government border: The case of citrus biosecurity management in West Timor, Indonesia', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 65–91.

Ndoen, M.L., Wallace, R. and Mampouw, H.L. (2011), 'Accessing Local Knowledge to Achieve Economic and Social Sustainability', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 163–181.

Royce, P. (2011), 'Using a community approach to foster effective biosecurity practices across social borders', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 93–107.

Surata, S.P.K. (2011), 'Bridging Cross-Cultural Knowledge Through Bilingual Biosecurity Glossary', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 129–143.

Wallace, R. (2011), 'Social Partnerships in Learning: Engaging Local, Regional and National partners in Plant Biosecurity Management', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 109–125.

Wallace, R., Mudita, I.W. and Natonis, R.L. (2011), 'Engaging Biosecurity Workforces through Mobile Learning and Technologies in Community Management and Biosecurity Research', in Falk, I., Wallace, R. and Ndoen, M.L. (eds.), *Managing Plant Biosecurity Across Borders*, Springer, Dordrecht, pp. 199–212.

Williams, K.J., Low-Choy, S., Rochester, W. and Alston, C. (2012), 'Using Bayesian mixture models that combine expert knowledge and GIS data to define ecoregions', in Ajith, H., Perera, C., Drew, A. and Johnson, C.J. (eds.), *Expert Knowledge and its application in Landscape Ecology*, Springer, New York, pp. 229–251.

Journal articles

Baker, R.H.A., Benninga, J., Bremmer, J., Brunel, S., Dupin, M., Eyre, D., Ilieva, Z., Jarošík, V., Kehlenbeck, H., Kriticos, D.J., Makowski, D., Pergl, J., Reynaud, P., Robinet, C., Soliman, T., Van der Werf, W. and Worner, S. (2012), 'A decision-support scheme for mapping endangered areas in pest risk analysis', *Bulletin OEPP/EPPO Bulletin*, 42(1), pp. 65–73.

Banks, N.C., Hodda, M., Singh, S.K. and Matveeva, E.M. (2012), 'Dispersal of Potato Cyst Nematodes Measured Using Historical and Spatial Statistical Analyses', *Phytopathology*, 102(6), pp. 620–626.

Carrasco, L.R., Cook, D., Baker, R., MacLeod, A., Knight, J.D. and Mumford, J.D. (2012), 'Towards the integration of spread and economic impacts of biological invasions in a landscape of learning and imitating agents', *Ecological Economics*, 76, pp. 95–103.

Castalanelli, M.A., Baker, A.M., Munyard, K.A., Grimm, M. and Groth, D.M. (2012), 'Molecular phylogeny supports the paraphyletic nature of the genus *Trogoderma* (Coleoptera: Dermestidae) collected in the Australasian ecozone', *Bulletin of Entomological Research*, 102, pp. 17–28.

Clifford, S., Hussein, T., Mengersen, K. and Morawska, L. (2011), 'Using the Generalised Additive Model to model the Particle Number Count of ultrafine particles', *Atmospheric Environment*, 45(32), pp. 5934–5945.

Cook, D.C., Carrasco, L.R., Paini, D.R. and Fraser, R.W. (2011), 'Estimating the Social Welfare Effects of New Zealand Apple Imports', *Australian Journal of Agricultural and Resource Economics*, 55(4), pp. 599–620.

Cook, D.C., Fraser, R.W., Paini, D.R., Warden, A.C., Lonsdale, W.M. and De Barro P. J. (2011), 'Biosecurity and Yield Improvement Technologies Are Strategic Complements in the Fight against Food Insecurity', *PLoS ONE*, 6(10), pp. 1–7.

Emery, R.N., Nayak, M.K. and Holloway, J.C. (2011), 'Lessons learned from phosphine resistance monitoring in Australia', *Stewart Postharvest Review*, 7(3), pp. 1–8.

Ero, M.M. and Clarke, A.R. (2012), 'Host location by the fruit fly parasitoid *Diachasmimorpha krausii* (Sonan) (Hymenoptera: Braconidae): role of fruit fly species, life stage and host plant', *Agricultural and Forest Entomology*, 14(1), pp. 101–110.

Ero, M.M., Hamacek, E. and Clarke, A.R. (2012), 'Foraging behaviours of *Diachasmimorpha kraussii* (Fullaway) (Hymenoptera: Braconidae) and its host *Bactrocera tryoni* (Froggatt) (Diptera: Tephritidae) in a nectarine (*Prunus persica* (L.) Batsch var. *nectarina* (Aiton) Maxim) orchard', *Australian Journal of Entomology*, 50(3), pp. 234–240.

Eyre, D., Baker, R.H.A., Brunel, S., Dupin, M., Jarošik, V., Kriticos, D.J., Makowski, D., Pergl, J., Reynaud, P., Robinet, C. and Worner, S. (2012), 'Rating and mapping the suitability of the climate for pest risk analysis', *Bulletin OEPP/EPPO Bulletin*, 42(1), pp. 48–55.

Finlay, K.J. and Luck, J.E. (2011), 'Response of the bird cherry oat aphid (*Rhopalosiphum padi*) to climate change in relation to its pest status, vectoring potential and function in a crop-vector-virus pathosystem', *Agriculture, Ecosystems and Environment*, 144(1), pp. 405–421.

Fisher, R., O'Leary, R.A., Low-Choy, S., Mengersen, K. and Caley, M.J. (2012), 'A software template for elicitation of expert knowledge about species richness or similar counts', *Environmental Modelling & Software*, 30, pp. 1–14.

Fisher, R., O'Leary, R.A., Low-Choy, S., Mengersen, K. and Caley, M.J. (2012), 'A software tool for elicitation of expert knowledge about species richness or similar counts', *Environmental Modelling & Software*, 30, pp. 1–14.

García Adeva, J.J. and Reynolds, M. (2012), 'Web-based Simulation to Support Decision Making in Bactrocera Fruit Fly Biosecurity', *Ecological Informatics*, 9, pp. 19–36.

García Adeva, J.J., Botha, J. and Reynolds, M.A. (2012), 'Simulation Modelling Approach to Forecast Establishment and Spread of Bactrocera Fruit Flies', *Ecological Modelling*, 227, pp. 93–108.

Gonzalez, F., Castro, M.P.G., Narayan, P., Walker, R. and Zeller, L. (2011), 'Development of an autonomous unmanned aerial system to collect time-stamped samples from the atmosphere and localize potential pathogen sources', *Journal of Field Robotics*, 28(6), pp. 961–976.

Guichard, S., Kriticos, D.J., Leriche, A., Kean, J.M. and Worner, S.P. (2012), 'Individual-based modelling of moth dispersal to improve biosecurity incursion response', *Journal of Applied Ecology*, 49(1), pp. 287–296.

Hamilton, G. and Elmouttie, D. (2011), 'Insect distributions and sampling protocols for stored commodities', *Stewart Postharvest Review*, 7(3), pp. 1–5.

Hu, W., O'Leary, R.A., Mengersen, K. and Low Choy, S. (2011), 'Bayesian classification and regression trees for predicting incidence of cryptosporidiosis', *PLoS ONE*, 6(8), pp. 1–8.

Ireland, K.B., Hüberli, D., Dell, B., Smith, I.W., Rizzo, D.M. and Hardy, G.E.St.J. (2012), 'Potential susceptibility of Australian native plant species to branch dieback and bole canker diseases caused by *Phytophthora ramorum*', *Plant Pathology*, 61(2), pp. 234-246.

Jackson, S.L. and Bayliss, K.L. (2011), 'Spore traps need improvement to fulfil plant biosecurity requirements', *Plant Pathology*, 60(5), pp. 801–810.

Jagadeesan, R., Collins, P.J., Daglish, G., Ebert, P.R. and Schlipalius, D.I. (2011), 'Phosphine resistance in the Rust Red Flour Beetle, *Tribolium castaneum* (Coleoptera: Tenebrionidae): inheritance, gene interactions and fitness costs', *PLoS ONE*, 7(2), pp. 1–12.

Kehlenbeck, H., Robinet, C., van der Werf, W., Kriticos, D., Reynaud, P. and Baker, R. (2012), 'Modelling and mapping spread in pest risk analysis: a generic approach', *Bulletin OEPP/EPPO Bulletin*, 42(1), pp. 74–80.

Kriticos, D.J., Reynaud, P., Baker, R.H.A. and Eyre, D. (2012), 'Estimating the global area of potential establishment for the western corn rootworm (*Diabrotica virgiferavirgifera*) under rain-fed and irrigated agriculture', *Bulletin OEPP/EPPO Bulletin*, 42(1), pp. 56–64.

Kriticos, D.J., Webber, B.L., Leriche, A., Ota, N., Bathlos, J., Macadam, I. and Scott, J.K. (2012), 'CliMond: global high resolution historical and future scenario climate surfaces for bioclimatic modelling', *Methods in Ecology and Evolution*, 3(1), pp. 53–64.

Liu, S., Walshe, T., Long, G. and Cook, D. (2012), 'Evaluation of Potential Responses to Invasive Non-Native Species with Structured Decision Making', *Conservation Biology*, 26(3), pp. 539–546.

Liu, S., Hurley, M., Lowell, K.E., Siddique, A-B. M., Diggle, A. and Cook D.C. (2011), 'An integrated decision-support approach in prioritizing risks of non-indigenous species in the face of high uncertainty', *Ecological Economics*, 70, pp. 1924–1930.

Liu, S., Sheppard, A., Kriticos, D. and Cook, D. (2011), 'Incorporating uncertainty and social values in managing invasive alien species: a deliberative multi-criteria evaluation approach', *Biological Invasions*, 13, pp. 2323–2337.

Martin, T.G., Burgman, M.A., Fidler, F., Kuhnert, P.M., Low-Choy, S., McBride, M. and Mengersen, K. (2012), 'Eliciting Expert Knowledge in Conservation Science', *Conservation Biology*, 26(1), pp. 29–38.

Mau, Y.S., Collins, P.J., Daglish, G.J., Nayak, M.K. and Ebert, P.R. (2012), 'The *rph2* gene is responsible for high level resistance to phosphine in independent field strains of *Rhyzopertha dominica*', *PLoS ONE*, 7(3), pp. 1–12.

Mau, Y.S., Collins, P.J., Daglish, G.J., Nayak, M.K., Pavic, H. and Ebert, P.R. (2012), 'The *rph1* Gene Is a Common Contributor to the Evolution of Phosphine Resistance in Independent Field Isolates of *Rhyzopertha Dominica*', *PLoS ONE*, 7(2), pp. 1–13.

McKirdy, S., Rodoni, B., Moran, J. and Sharma, S. (2012), 'Microbial threat– a growing challenge for plant biosecurity', *Microbiology Australia*, 33(1), pp. 12–14.

Paini, D.R., Bianchi, F.J.J.A., Northfield, T.D. and De Barro, P.J. (2011), 'Predicting invasive fungal pathogen using invasive pest assemblages: testing model predictions in a virtual world', *PLoS ONE*, 6(10), pp. 1–9.

Rathe, A., Pilkington, L., Gurr, G. and Daugherty, M.P. (2012), 'Potential for persistence and within-plant movement of *Xylella fastidiosa* in Australian native plants', *Australasian Plant Pathology*, 41(4), pp. 405–412.

Rea, A.J., Burgess, T.I., Hardy, G., Stukely, M.J.C. and Jung, T. (2011), 'Two novel and potentially endemic species of *Phytophthora* associated with episodic dieback of Kwongan vegatation in the south-west of Western Australia', *Plant Pathology*, 60(6), pp. 1055–1068.

Ren, Y., Lee, B., Padovan, B. and Cai, L. (2012), 'Ethyl formate (EF) plus methyl isothiocyanate (MITC) is a potential liquid fumigant for stored grains', *Pest Management Science*, 68(2), pp. 194–201.

Ren, Y.L., Demarchelier, J. and Healy, P. (2011), 'Effect of Carbonyl Sulphide (COS), Ethyl Formate (EF) and Carbon Disulphide (CS2) on the Malting Quality of Barley and the Flavour Profile of Beer', *Journal of the Institute of Brewing*, 117(4), pp. 593–599.

Renton, M., Shackelford, N. and Standish, R.J. (2012), 'Habitat restoration will help some functional plant types persist under climate change in fragmented landscapes', *Global Change Biology*, 18(6), pp. 2057–2070.

Ridley, A.W., Burrill, P.R., Cook, C. and Daglish, G.J. (2011), 'Phosphine fumigation of silo bags', *Journal of Stored Products Research*, 47(4), pp. 349–356.

Ridley, A.W., Schlipalius, D.I. and Daglish, G.J. (2012), 'Reproduction of phosphine resistant *Rhyzopertha dominica* (F.) following sublethal exposure to phosphine', *Biological Invasions*, 48, pp. 106–110.

Savage, D., Barbetti, M.J., MacLeod, W.J., Salam, M.U. and Renton, M. (2012), 'Mobile traps are better than stationary traps for surveillance of airborne fungal spores', *Crop Protection*, 36, pp. 23–30.

Savage, D., Barbetti, M.J., MacLeod, W.J., Salam, M.U. and Renton, M. (2012), 'Seasonal and diurnal patterns of spore release can significantly affect the proportion of spores expected to undergo long-distance dispersal', *Microbial Ecology*, 63(3), pp. 578–585.

Schutze, M.K., Jessup, A. and Clarke, A.R. (2012), 'Wing shape as a potential discriminator of morphologically similar pest taxa within the *Bactrocera dorsalis* species complex (Diptera: Tephritidae)', *Bulletin of Entomological Research*, 102(1), pp. 103–11.

Shi, M. and Renton, M. (2011), 'Numerical algorithms for estimation and calculation of parameters in modelling pest population dynamics and evolution of resistance', *Journal of Mathematical Biosciences*, 223(2), pp. 77–89.

Soopaya, R., Stringer, L.D., Woods, B., Stephens, A.E., Butler, R.C., Lacey, I., Kaur, A. and Suckling, D.M. (2011), 'Radiation biology and inherited sterility in light-brown apple moth (Lepidoptera: Tortricidae): developing a sterile insect release program', *Journal of Economic Entomology*, 104(6), pp. 1999–2008.

Spinner, J.E., Cowling, A.M., Gurr, G.M., Jessup, A.J. and Reynolds, O.L. (2011), 'Parasitoid fauna of Queensland fruit fly, *Bactrocera tryoni* Froggatt (Diptera: Tephritidae) in inland New South Wales, Australia and their potential for use in augmentative biological control', *Australian Journal of Entomology*, 50(4), pp. 445–452.

Stanaway, M.A., Mengersen, K.L. and Reeves, R. (2011), 'Hierarchical Bayesian modelling of early detection surveillance for plant pest invasions', *Environmental and Ecological Statistics*, 18(3), pp. 569–591.

Stanaway, M.A., Reeves, R. and Mengersen, K.L. (2011), 'Hierarchical Bayesian Modelling of Plant Pest Invasions with Human-Mediated Dispersal', *Ecological Modelling*, 222(19), pp. 3531–3540.

Suckling, D.M., Stringer, L.D., Mitchell, V.J., Sullivan, T.E.S., Sullivan, N.J., Simmons, G.S., Barrington, A.M. and El-Sayed, A.M. (2011), 'Comparative Fitness of Irradiated Light Brown Apple Moths (Lepidoptera: Tortricidae) in a Wind Tunnel, Hedgerow, and Vineyard', *Journal of Economic Entomology*, 104(4), pp. 1301–1308.

Webber, B.L., Yates, C.J., Le Maitre, D.C., Scott, J.K., Kriticos, D.J., Ota, N., McNeil, A., Le Roux, J.J. and Midgley, G.F. (2011), 'Modelling horses for novel climate courses: insights from projecting potential distributions of native and alien Australian acacias with correlative and mechanistic models', *Diveristy and Distrbutions*, 17(5), pp. 978–1000.

Wright, D. (2012), 'How the misidentification of a pathogen can cause an emergency response – a real life case study of an Australian grain export incident', *Microbiology Australia*, 33(1), pp. 29–30.

Wright, D. and You, M. (2012), 'Can we use crime scene investigation methods in plant pathology', *Microbiology Australia*, 33(1), pp. 40–41.

Zhang, B., Edwards, O.R., Kang, L. and Fuller, S.J. (2012), 'Russian wheat aphids (*Diuraphis noxia*) in China: native range expansion or recent introduction?', *Molecular Ecology*, 21(9), pp. 2130–2144.

Zheng, L., Gibbs, M., Gibbs, A. and Rodoni, B. (2011), 'First report of a newly detected potyvirus, Commelina mild mosaic virus, infecting *Commelina spp.* in Australia', *Australasian Plant Disease Notes*, 6(1), pp. 11–15.

Conference proceedings papers

García Adeva, J.J, Lach, L. and Reynolds, M. (2011), 'Simulation of Honeybee Nectar Foraging for Determining Effects on Local Flora', in Chan, F., Marinova, D. and Anderssen, R.S. (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011, pp. 2507–2513.

Bennett, J.C., Diggle, A., Evans, F. and Renton, M. (2011), 'Towards measures of the eradicability of rain-splashed crop diseases', in Chan, F., Marinova, D. and Anderssen, R.S. (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011, pp. 2486–2492.

Low-Choy, S., Hammond, N., Penrose, L., Anderson, C. and Taylor, S. (2011), 'Dispersal in a hurry: Bayesian learning from surveillance to establish area freedom from plant pests with early dispersal', in Chan, F., Marinova, D. and Anderssen, R.S. (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011, pp. 2521–2527.

O'Leary, R., Low-Choy, S., Mengersen, K. and Caley, M. (2011), 'What is an expert?', in Chan, F., Marinova, D. and Anderssen, R.S. (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011, pp. 2149–2155.

Parry, H.R., Aurambout, J-P. and Kriticos, D.J. (2011), 'Having your cake and eating it: A modelling framework to combine process-based population dynamics and dispersal simulation', in Chan, F., Marinova, D. and Anderssen, R.S. (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011, pp. 2535–2541.

Renton, M., Savage, D. and Chopard, J. (2011), 'A general spatially-explicit model to inform rapid response to new biological invasions: why do we need one and what should it look like?' in Chan, F., Marinova, D. and Anderssen, R.S. (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011, pp. 2542–2548.

Sadler, R.J., Florec, V., White, B. and Dominiak, B.C. (2011), 'Calibrating a Jump-Diffusion Model of an endemic invasive: Metamodels, statistics and Qfly', in Chan, F., Marinova, D. and Anderssen, R.S. (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011, pp. 2549–2555.

Savage, D., Barbetti, M., MacLeod, W., Salam, M. and Renton, M. (2011), 'Modelling the effects of release timing on wind-assisted dispersal of passive propagules', in Chan, F., Marinova, D. and Anderssen, R.S. (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011, pp. 2556–2562.

Shackelford, N., Renton, M., Perring, M.P. and Hobbs, R.J. (2011), 'Management implications of modeling invasion by *Allocasuarina huegeliana* in kwongan heathland', in Chan, F., Marinova, D. and Anderssen, R.S. (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011, pp. 2563–2569.

Shi, M., Renton, M. and Collins, P.J. (2011), 'Mortality estimation for individual-based simulations of phosphine resistance in lesser grain borer (*Rhyzopertha dominica*)', in Chan, F., Marinova, D. and Anderssen, R.S. (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011, pp. 352–358.

Publications and reports for end-users

Collins, P., Ridley, A. and Saunders, C. (2011), 'Aeration's Dry Argument', Ground Cover DVD, September 2011.

CRC for National Plant Biosecurity (2011), *The Leaflet*, December 2011.

CRC for National Plant Biosecurity (2011), *The Leaflet*, July 2011.

CRC for National Plant Biosecurity (2011), *The Leaflet*, November 2011.

CRC for National Plant Biosecurity (2011), *The Leaflet*, September 2011.

CRC for National Plant Biosecurity (2012), *The Leaflet*, February 2012.

CRC for National Plant Biosecurity (2012), *The Leaflet*, May 2012.

Ireland, K. (2012), '*Phytophthora ramorum*: susceptibility of Australian plants, potential geographic range and science into policy and management', *California Oak Mortality Task Force newsletter*, February 2012.

Norwood, C. (2011), 'Sun power boosts grain protection' *GRDC Ground Cover Issue 94*, 17 August.

Singh, S., Conde, B. and Hodda, M. (2012), 'Root knot nematode: symptoms and diagnosis of an important pest of vegetables in the Northern Territory', *The Plant Industries NT Newsletter*, March 2012, pp. 2–4.

Singh, S., Hodda, M. and Conde, B. (2012), 'Meloidogyne incognita (Kofoid & White, 1919) Chitwood, 1949', *Pathogen of the Month*, Australasian Plant Pathology Society, April 2012.

Stevens, M. and Warren, G. (2012), 'The secret lives of grain beetles', *IREC Farmers' Newsletter*, No. 186, Autumn 2012, pp. 22–25.

CRC PLANTbiosecurity

The Cooperative Research Centre for National Plant Biosecurity is a collaborative venture between the following core and supporting organisations.

CORE PARTICIPANTS

Australian Government
Department of Agriculture, Fisheries and Forestry

CBH GROUP
Linking growers to customers

Charles Darwin UNIVERSITY

CSIRO

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GrainCorp

GRDC
Grains Research & Development Corporation

NSW GOVERNMENT Industry & Investment

Murdoch UNIVERSITY

LA TROBE UNIVERSITY

Plant Health AUSTRALIA

Queensland Government

QUT

Saturn Biotech
Providing Assurance for Agriculture

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Victoria

VITERRA

SUPPORTING PARTICIPANTS

www.cabi.org

CHARLES STURT UNIVERSITY

HAL
Know-how for Horticulture™

Northern Territory Government

Southern Cross UNIVERSITY
A new way to think

THE UNIVERSITY OF ADELAIDE AUSTRALIA

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence

An Australian Government Initiative
CRC AUSTRALIA

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