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partners

IN RESEARCH FOR DEVELOPMENT

ACIAR in AUSTRALIA

Benefits to Australia

$31.9 billion is a significant return on investment in any language, the more so when the upfront expenditure is about $2 billion. A recent meta-analysis of impacts from a selection of ACIAR projects, independently assessed to determine economic returns, found $31.9 billion as the total benefits accruing. The $2.3 billion is the total expenditure by ACIAR in three decades of research.

Some $2.2 billion of those benefits accrue back to Australian agriculture. This dividend reflects the flow of benefits between partner countries (more than 90% of project outcomes) and Australia (around 7–10% of returns). ACIAR's international reputation is built on the outcomes of projects reaching poor smallholder farmers, helping them to escape poverty. Inevitably the returns overseas will be greater because that is the primary focus of the research and the base to build on is far lower than that of Australian agriculture.

ACIAR achieves such high returns by creating partnerships that meet the priorities of our partner countries. Because these partnerships intersect with Australian expertise, some benefits inevitably accrue back home. To paraphrase Derek Tribe, by doing good overseas we also do well here in Australia.

These benefits are not exclusively spill-over benefits in the true meaning of that term; benefits come from engaging Australian scientists on mutual problems shared with developing countries. Doing research that links Australian and partner country research scientists provides a domestic focus on similar problems.

To paraphrase Derek Tribe, by doing good overseas we also do well here in Australia.

From this research Australia gains:

- knowledge and expertise, building our domestic research capacity
- exposure to the control and management of exotic pests and diseases offshore
- potential trade opportunities
- access to germplasm for the species – all introduced – that we farm
- funding for some niche industries and commodities otherwise attracting limited or no research
- new industries and commodity opportunities
- innovations in farm management and improved approaches to regulatory compliance
- improved land, soils and water management.

These benefits add significantly to a range of Australian agricultural initiatives. This issue of *Partners* tells some of the stories of those benefits and the people who help make them happen.

People such as Dr Jes Sammut, whose involvement with ACIAR highlights how this engagement works so well domestically as well as internationally. His work with ACIAR has led to new breakthroughs on a previously little-understood fish disease and its link to the exposure of soils by farmers. The result is a national management strategy in Australia and a range of policy initiatives in Indonesia.

Or Dr Sam Periyannan, who grew up on a farm in India and who has made a crucial contribution to a joint ACIAR, CSIRO and Grains Research and Development Corporation study that isolated a gene providing resistance against the stem rust Ug99, which was threatening wheat yields across the Middle East and India and is considered a grave threat to Australia's industry, should it find its way here.

Among the contributions to Australian agriculture also reported are: research into cereal drought tolerance; the emergence of an Australian sandalwood industry; a range of efforts to strengthen offshore quarantine and to protect fishing resources shared with our nearest neighbours; research that is helping Australian farmers save water; and the conservation of important germplasm. All have as a common feature: ACIAR research funding. The benefits that accrue are significant.

Through ACIAR's partnership model opportunities to link domestic skills and needs to international development help create wins for all partners.

As the CEO of Australia's National Farmers' Federation says on page 7: "Linking domestic RD&E priorities with ACIAR's work in developing countries is critical to ensuring that Australian agriculture continues to benefit from investment in international RD&E." ■

This issue…

ACIAR
aciar.gov.au

Australian Centre for International Agricultural Research (ACIAR), aciar.gov.au
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ACIAR ACTION

partners
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Partners in Research for Development is the flagship publication of the Australian Centre for International Agricultural Research (ACIAR). *Partners* presents articles that summarise results from ACIAR-sponsored research projects and puts ACIAR research initiatives into perspective. Technical enquiries will be passed on to the appropriate researchers for reply. Reprinting of articles, either whole or in part, is welcomed, provided that the source is acknowledged.

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For further information contact:
ACIAR Communications and Public Affairs, +61 2 6217 0500

Letters from readers are welcome and should be addressed to:
The Editor
Partners in Research for Development, ACIAR
GPO Box 1571, Canberra ACT 2601, Australia

Executive editor: **Warren Page**, ACIAR
Email: comms@aciar.gov.au Photos: All photos ACIAR unless credited

Managing editor: **Brad Collis**, Coretext Pty Ltd, coretext.com.au
Editor: **Dr Gio Braidotti**, Coretext Pty Ltd, coretext.com.au
Design and production: **Coretext Pty Ltd**, +61 3 9670 1168

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ACIAR IN AUSTRALIA

PHOTO: PAUL JONES

"Australia is uniquely placed to assist developing countries in the area of agriculture. We are recognised as having particular expertise and experience in agricultural research and development over a wide range of climatic and environmental conditions, from dryland farming to tropical livestock and agricultural production."

— Second Reading Speech to the Australian Parliament, 1981, on the introduction of the ACIAR Act.

- Australia is a net food exporting country and about 70% of food produced is exported.
- Australia is one of the world's largest agricultural export nations for wheat, barley, beef, dairy products, wine and wool.
- Australian agriculture feeds 60 million people directly and contributes to the food security of 400 million more through research advances.
- Australia ranks 16th in the world for spending on agricultural R&D.
- Agriculture in 2011 used 53% of land and 55% of water resources.
- In 2011, the sector contributed 2.4% of GDP ($1.285 trillion), 5% of Australia's total exports ($13.2 billion) and employed 279,000 Australians directly.
- Over the three decades to 2011, the number of Australian farmers has declined by 40% but the value of farm exports increased by an average of 5% per year.
- In irrigated agriculture, water use declined 43% while production rose 39%.
- A third of agricultural businesses have reported setting aside a combined 8.4 million hectares of land for conservation or protection purposes.

AUSTRALIAN AGRICULTURE

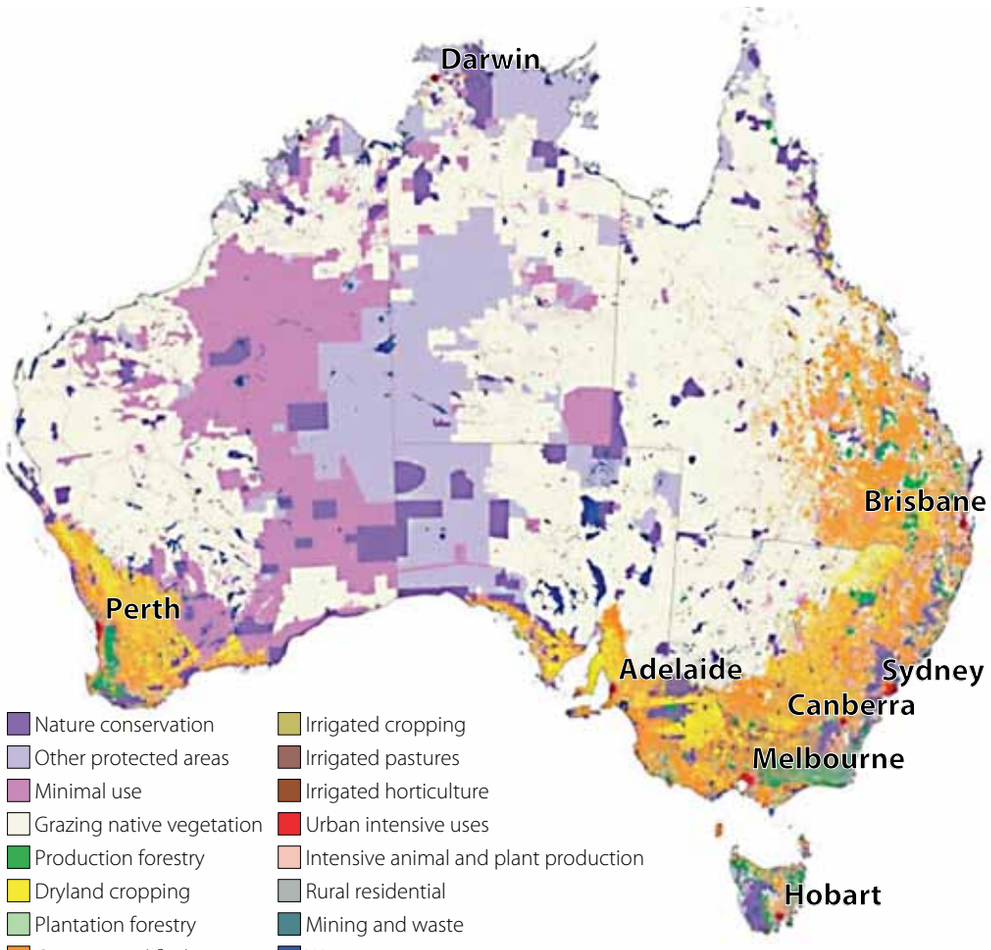
- **Australia has a population of 23 million, one-third of which lives in regional areas, and is home to one of the world's oldest living cultures—the Aboriginal peoples.**
- **Australia is one of the most diverse multicultural nations. Almost half of the population comprises immigrants from more than 200 countries or their children—9% with Asian ancestry.**
- **Australia is the world's driest inhabited continent and the largest island. It sustains 10% of the world's biodiversity.**
- **Australia was a founding member of the United Nations and is the 12th largest contributor to the UN regular and peacekeeping budgets.**
- **In 2012, two million Australian households donated to non-government organisations—one of the highest private donor rates in the world.**
- **Australia's research and development expenditure has grown at almost twice the OECD average: 9.9% between 2000 and 2008.**
- **Australian inventions include the bionic ear, high-speed WiFi, the black box flight recorder and the cervical cancer vaccine.**
- **In the decade to 2011, household water consumption reduced 35% per capita in response to pervasive drought conditions.**
- **Per capita, Australia's emissions of greenhouse gases are among the highest in the world.**

PHOTO: PAUL JONES

THE AUSTRALIAN CENTRE FOR INTERNATIONAL AGRICULTURAL RESEARCH

- ACIAR aims to leverage Australia's advanced agricultural science expertise in the arena of international development, sustainability and food security.
- ACIAR recognises that Australia shares similar production challenges with developing countries and benefits greatly from international engagement in seeking solutions.
- ACIAR invests in agricultural science and extension in Australia, via International Agricultural Research Centres (IARCs), and in more than 40 developing countries.
- Since 1982 ACIAR has commissioned and managed more than 600 research projects involving more than 50 Australian research bodies and 150 institutions in partner countries.
- Independent impact assessments of 130 ACIAR projects have demonstrated estimated total benefits of $31.9 billion from a total project expenditure of $379 million.
- In 2012–13, ACIAR administered and managed more than $73 million in project funds, $77 million in multilateral programs with the IARCs, and $7 million in building research capacity.
- There are 93 active postgraduate fellowships for scientists from developing countries associated with ACIAR projects, with 257 scientists completing studies at either masters or PhD level.

SOURCES:
SUSTAINABLE AUSTRALIA REPORT,
NATIONAL SUSTAINABILITY COUNCIL;
ACIAR STRATEGIC FRAMEWORK ON AGRICULTURAL RESEARCH;
ACIAR ANNUAL REPORT 2011–12;
DFAT REPORT, FEEDING THE FUTURE; ABARES; DAFF.



Source: Department of Foreign Affairs and Trade (DFAT) report *Feeding the future*, December 2012
http://www.dfat.gov.au/publications/feeding-the-future/images/Map_Land_Use.jpg

LAND USE IN AUSTRALIA

In 2011 Australia ranked 17th among food exporting countries, with 2% of total global exports. These exported commodities all involve species that are exotic to Australia. Adapting these foreign species to growing conditions in Australia has created a strong flow of benefits from engaging internationally with agricultural R&D organisations.

Australia is free from many pests and diseases found in other countries, including major livestock diseases such as bovine spongiform encephalopathy (BSE) and foot and mouth disease (FMD). Maintaining this largely disease-free status is a priority. So too is maintaining high levels of food safety, both for exports and domestic consumption. According to the OECD, Australia ranked equal first with Denmark and the UK for food safety performance in 2010.

Australia's agricultural production base is limited by poor soil quality, drought and frost. Compared with soils in the Northern Hemisphere, Australian soils have less organic matter, low levels of phosphorus and other nutrients, and poorer structure that results in reduced nutrient storage and water-holding capacity.

Excluding Antarctica, Australia is the driest continent, and agricultural productive capacity is affected by rainfall distribution. Long-term average annual rainfall varies from less than 300 millimetres per year in central Australia to more than 3,000 mm in northern Queensland. Run-off into rivers is low—on average, only a tenth of this rainfall is captured in rivers or subterranean aquifers—compared with a world average of 65%.

FROM AUSTRALIA TO THE WORLD: Growing our knowledge and the world's farmers

The vital importance of increased investment in agricultural research, development and extension to both Australia and the world is discussed by Matt Linnegar, chief executive officer of the National Farmers' Federation, Australia's peak body representing farmers and the agricultural sector.

In coming years, the world's population is set to dramatically increase. By 2050, the current population of seven billion is projected to expand to more than nine billion—an increase of two billion people in less than 40 years.

While there are many uncertainties in global trends affecting Australia's future, we can be certain that there will be more mouths to feed, leading to an increased demand for food to match.

At present, Australian farmers export approximately 60% of what they produce, contributing significantly to the food and fibre needs abroad.

As the world population grows and the market changes to reflect this, it is appropriate for Australia to seek to understand these trends and develop strategies to address them in the best interests of not only Australian consumers, but also Australian farmers.

That must include strategies to help Australian farmers better use their valuable resources—land, water and labour—to grow more food and fibre to help feed the growing world population.

Farmers already grow more food on less land than at any time in the world's history. But for farmers to continue to produce more with less, increased investment in innovation, research, development and extension (RD&E) in agriculture is crucial.

This is reflected in the Blueprint for Australian Agriculture, which was developed with the input of almost 4,000 farmers, transporters, retailers, consultants, rural businesses, agribusinesses, educators, governments, rural communities, community groups and consumers and was led by the National Farmers' Federation (NFF). It identified innovation and RD&E as a key priority for the agricultural sector to ensure it is able to meet future challenges and food demand.

The timing on this is critical. There has been little real growth in public investment in the RD&E needed to drive innovation in the sector since the 1970s and now Australia's agricultural sector is feeling the impact.

That is why the NFF has called for an increase in total national expenditure in agricultural RD&E, including both public and private investment, of 1% by 2015—an increase of $281 million over the next two years—and we have welcomed recent policy commitments that go some way to achieving this.

A ROLE FOR ACIAR

ACIAR's work in international RD&E contributes significantly to Australia's international aid priorities, helping to develop more sustainable agriculture systems specifically for developing countries in the five regions covered by its mandate.

Providing training and greater information and development opportunities for farmers in developing countries can have important flow-on effects for both the international and Australian agriculture sectors.

Assisting with agricultural development in developing countries helps boost the economies of these nations, lifting many people in rural areas out of poverty, and can at the same time provide potential positive benefits for Australian exporters in the long term.

Key to the continuing success of ACIAR is ensuring that a balance is achieved between investing in international RD&E and working with Australia's domestic agricultural RD&E system.

While Australian farmers generally support ongoing investment in improving sustainable agricultural production in developing countries, the challenge for the Australian Government and agricultural community is to maximise opportunities and realise dual benefits for both developing countries and Australian primary producers from this investment.

The research undertaken by ACIAR in developing countries does provide benefits to Australia through capacity building for Australian researchers and scientists, access to broader information and research on pests and weeds that could affect Australian agriculture, the ability to learn from agricultural practices in other countries, and even direct economic benefits.

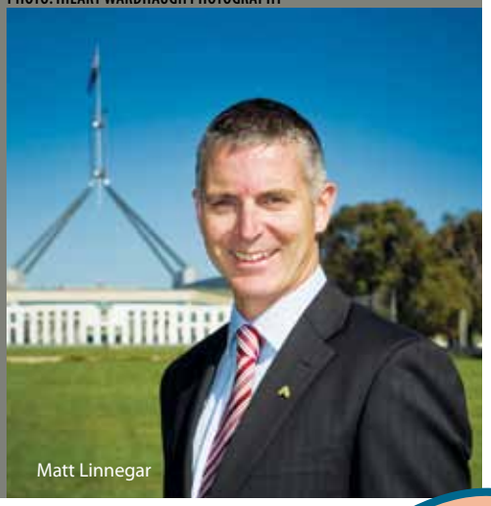
For example, an ACIAR-funded project was run from 1990 to 1995 titled 'Development of heat-treatment systems for quarantine disinfestation in tropical fruit', which sought to develop heat-based fruit fly disinfestation treatments for fruit and vegetables. In turn, this built capacity for such produce to meet the strict quarantine restrictions of several South-East Asian export markets.

One particularly lucrative market that was effectively barred to Australian exporters due to quarantine regulations was the Japanese mango market.

The ACIAR research project linked the Queensland Department of Primary Industries with various agencies in Thailand and the Philippines to develop mango-disinfestation treatment schedules that worked with rigorous quarantine systems.

As part of the project, market access for Australian mangoes into Japan was negotiated for the season of 1994–95 and continued to remain in place. Subsequently, mango trade with Japan continued to steadily increase, with the total gross benefit of the project to Australia estimated at $4.4 million.

PHOTO: HILARY WARDHAUGH PHOTOGRAPHY



Matt Linnegar

This is a direct benefit to Australian farmers from an ACIAR-funded project, and one that demonstrates the potential benefits that research undertaken overseas can have for the Australian agricultural sector.

The NFF is of the view that greater linkages between Australia's primary producers, RD&E experts and developing countries would lead to increased benefits for all parties involved, particularly in terms of encouraging new and fresh perspectives on issues being tackled on the Australian home front.

Linking domestic RD&E priorities with ACIAR's work in developing countries is critical to ensuring that Australian agriculture continues to benefit from investment in international RD&E.

It is also important that Australia's international work assists in building the number of agricultural scientists at home, to ensure that Australian farmers still have access to the latest information and advice while Australia is providing our depth of knowledge to developing countries.

FOOD SECURITY

One area that would benefit from greater linkages between Australian agriculture and RD&E in developing countries is food security—an issue that will increase in importance as the population continues to grow.

Government figures show that Australian farmers feed about 60 million people around the world: 20 million domestically and 40 million overseas. But as Professor Ian Chubb AC, Australia's chief scientist, recently said, through knowledge and research, Australia contributes to the diets of 400 million people worldwide.

This shows Australia's potential to play a vital role in developing international food security through RD&E, even more so than through the export of food.

ACIAR already does incredibly important work in this space, with research into potential pests and diseases ranging from stem rust to avian influenza, contributing to improved biosecurity outcomes across Australia and the world.

An example of this is the work underway between ACIAR, CSIRO, the Australian Grains Research and Development Corporation (GRDC) and other research bodies, including those based in India, on Ug99—a disease-causing fungus strain that attacks wheat crops.

Ug99 is one of the biggest threats to wheat production worldwide and ACIAR's investment in research and researchers has helped to identify one disease-resistance gene, *Sr33*, that protects wheat crops from all stem rust disease races, including Ug99. This is an excellent outcome for agriculture worldwide, with very positive implications for Australian farmers.

More projects like this, which build collaborative partnerships between Australian research bodies and global partners, are becoming increasingly important to address the many other critical issues affecting agriculture in Australia today.

Some other areas that require attention and could be better addressed through a collaborative international approach include:

- developing and adopting new plant varieties and technologies for tropical, arid and semi-arid regions
- sustainably integrating agriculture with the natural environment
- improving fertiliser, energy and water use efficiency
- reducing food wastage during harvest, marketing and transportation
- developing transparent and competitive commodity markets
- developing agricultural policy and governance arrangements
- improving effective farming practices and risk management strategies for seasonal and climatic variability, including recovery from natural disasters
- preserving soil fertility and nutrients.

Not only is RD&E investment in these areas critical for the continued growth and sustainability of Australian agriculture, but funding of such programs also provides opportunities for the development of international networks, improved communication and wider knowledge exchange.

As we continue working towards increasing the capacity of the Australian agricultural sector, the agricultural community welcomes the chance to work with ACIAR in developing closer linkages between domestic RD&E priorities and the valuable work that is being undertaken in developing countries.

With a unified approach and a focus on developing domestic opportunities of dual benefit, we believe that both the international and domestic agriculture sectors will continue to benefit from ACIAR's important work. ■

More information: www.nff.org.au

Farmers already grow more food on less land than at any time in the world's history. But for farmers to continue to produce more with less, increased investment in innovation, research, development and extension in agriculture is crucial.

Only as good as your people

ACIAR has been committed to capacity building for many years to deliver sustainable and lasting outcomes in agriculture and food security. The benefits—gains in scientific knowledge, capacity and networks—flow as much to Australia and its scientists as to the partners ACIAR works with.

BY DR WENDY HENDERSON

When ACIAR contributed to funding Jes Sammut's PhD back in the 1990s there was nothing to indicate how vast the outcomes were going to be for Australia. Dr Jes Sammut worked with Dr Dick Callinan to investigate disease outbreaks in fish that were affecting 80% of the Australian commercial catch. The project was run in partnership with Indonesia.

They found that the disease—known as 'red spot' (epizootic ulcerative syndrome)—was the result of a chain reaction inadvertently triggered by drainage of coastal wetlands to create land for farming and other uses.

In a case of unintended consequences, the land-use changes inadvertently exposed the acid sulfate soils that usually occur under other soil layers.

The run-off from these soils then entered the local estuaries during wet weather, making the water more acidic than usual, often more acidic than vinegar.

Dr Callinan had previously found that a fungus was involved in the disease, but infection only occurred if fish had skin damage.

Together, Dr Sammut and Dr Callinan found that acidic water could cause sufficient skin damage to enable the fungus to infect fish and cause disease. They also found that acidic water caused skin and gill damage that led to catastrophic fish kills in estuaries.

The discovery was significant enough to lead to a summit on the problem of acid sulfate soils in New South Wales. The research findings had cleared an information bottleneck that had previously fuelled tensions between stakeholders.

Dr Jes Sammut at the Markham Valley cooperative fish farms in Papua New Guinea with fish farmers involved with mutually beneficial ACIAR aquaculture research on feed formulations, pond site selection and pond management.

An advisory and technical committee on acid sulfate soil was formed in NSW, and

AUSTRALIAN AID INSPIRES YOUNG SCIENTISTS

ACIAR projects are inspiring young Australian scientists to pursue careers in agriculture at a time when universities are struggling to attract and retain agricultural science students.

BY MELISSA BRANAGH-MCCONACHY

Dr Darryl Savage says applying his agricultural expertise to benefit developing countries is the most rewarding experience of his career.

The agricultural science lecturer and researcher, based at NSW's University of New England, is investigating how beef cattle can contribute to food security in Asia as part of a project funded by ACIAR.

"We aim to alleviate poverty in Cambodia by increasing beef productivity, improving biosecurity and identifying new markets for red meat in Vietnam and southern China," Dr Savage says.

The project, which commenced in 2007, is driving significant change in the former war-ravaged nation.

Along with growing demand for cattle production, the introduction of new cattle raising approaches has reduced the need for child labour on smallholder farms, increasing school attendance.

"One of the Cambodian farmers' highest priorities is education for their children, so technology adoption was a no-brainer," Dr Savage says.

The project team has also partnered with Cambodian universities and trains undergraduate students in research skills, a process that is inspiring many to undertake further studies in Australia.

"The legacy of this project is much greater than the project itself; it is creating life-changing opportunities with long-term gains and sustainable outcomes," Dr Savage says.

"And there are net benefits for Australia. Foot and mouth disease is endemic in Cambodia, so understanding how to reduce its spread is very important for us."

According to the United Nations, one billion people worldwide are malnourished, largely due to protein deficiency.

"Red meat is the world's number one source of protein and I am convinced we can improve the efficiency of how it becomes available by reducing the environmental impact of methane emissions through animal selection, nutrition and better production systems, which also improves productivity," Dr Savage says. "UNE is a major player in this field of research.

"Australia is one of the most efficient red meat producers in the world so we have an important role to play in food security, which creates wonderful opportunities in science at both the applied and high-tech ends.

"And part of our responsibility is passing knowledge on overseas."

another later in Queensland. A national committee was formed some time later because the problem of acid sulfate soils and their impact became a national concern.

Environmental plans have since been developed not only for the local region, but also at a national level.

The National Strategy for the Management of Coastal Acid Sulfate Soils is considered critical to resolving acid sulfate soil issues affecting industrial, environmental, agricultural and residential developments.

Development proposals in the coastal zone must now consider acid sulfate soils as a risk factor. Many coastal councils across Australia have developed policies and procedures to assess the risks associated with developing acid sulfate soils.

This research has led to substantial changes in environmental policy, land management practices and community awareness that are still ongoing since Dr Sammut's and Dr Callinan's work in the 1990s.

It has also triggered the provision of funding for further research—for example on oysters—that will benefit the Australian environment, commercial and recreational fishing and the aquaculture industry.

The research also led to major projects in Indonesia, where acid sulfate soils are a threat to the livelihoods of coastal communities and to important outputs for various aquaculture reconstruction projects in Aceh following the 2004 Tsunami.

Dr Sammut says that research activities in developing countries provide valuable experience on topics of practical importance to Australia. This is especially true for aquaculture—broodstock and fingerling management—since Australia uses some of the same species, such as grouper and tiger shrimp.

Other impacts relate to experience and knowledge gained on environmental and production limits. This can involve issues such as the types of environment that can sustain agriculture or the optimal environmental conditions and risk factors. Affected areas include soil processes, rice and shrimp farming practices, and farming fish in earthen ponds.

The costs of research can also be lower and may even permit research that would not be done at all in Australia.

"For example, aquaculture research is on the decline here, so ACIAR can enable Australian researchers to maintain and grow research programs that bring benefits to our local industries," Dr Sammut says.

There are numerous examples of benefits that reach Australia.

Several projects on shrimp, mollusc and fish farming in Vietnam, Indonesia and elsewhere included studies of disease spread and management. Gaining a better understanding means Australia is better prepared to respond to a disease outbreak, and also to have improved quarantine protocols.

Shark research in Indonesia by CSIRO assessed ocean stocks in internationally shared waters to help avoid mismanagement by overfishing. New shark and ray species were discovered and this research led to a manual on shark and ray species.

The manual enables more accurate identification of sharks and rays. Similar research on sustainably managing sharks will soon commence in Papua New Guinea. It is important for Australia to know which species are out there and what is being fished (and how) by our neighbours.

Australia plays an important role in protecting these species, which are apex predators at the top of the food chain. Agreements need to be reached to allow the equitable exploitation and proper management of the species.

The ultimate results are a win–win: sustainable fishing practices for our neighbours and a positive environmental outcome for Australia. ■

More information: National Strategy for the Management of Coastal Acid Sulfate Soils, www.mincos.gov.au/__data/assets/pdf_file/0003/316065/natass.pdf

Dr Savage regularly discusses his work with groups that promote the uptake of science by young Australians and answers questions about his own career path. This started with a degree in agricultural science at the University of Queensland and has included stints as a jackaroo, running research programs in the Northern Territory's Barkly Tableland, and completing doctoral studies on beef cattle nutrition and reproduction. ■

For Dr Darryl Savage a career in science as a cattle researcher proved more satisfying as a result of working on an ACIAR project.

PHOTO: PAUL JONES

There are about 135,000 farm businesses across Australia. Many opt to contribute directly to funding agricultural research through a levy on sales that is matched by the Australian Government.

THE FUNDS THAT MAKE A DIFFERENCE

Although primarily identified as an 'aid agency', ACIAR also plays a vital role on behalf of Australian agriculture as a provider of research funds and it is one of the few such providers in Australia with a truly international reach.

BY DR GIO BRAIDOTTI

ACIAR has a dual identity that allows it to occupy a unique position in Australia's innovation system. The centre is part of Australia's aid program but also functions as a provider of research funds that benefit Australian scientific capacity and agriculture.

As such, ACIAR increases the overall research base dealing with agricultural issues of interest to Australia.

This aspect of ACIAR's character was noted by the Centre for International Economics (CIE) in its submission to the Productivity Commission Study on Public Support for Science and Innovation:

> *In particular, ACIAR's emphasis on agricultural research to achieve sustainable development and natural resource management funds research that directly contributes to Australia's pursuit of better outcomes in areas such as water management, soil degradation, biodiversity and climate change responses. Similarly, ACIAR's projects dealing with food safety, animal and crop health and biosecurity concur with and contribute to Australia's need to maintain and enhance its agricultural and food health and safety status.*

Independent economic assessment of impacts associated with ACIAR projects provides consistent evidence for large returns on investment to Australian agriculture.

In 2006, it was estimated that 65 ACIAR projects analysed delivered to Australian agriculture $768 million worth of benefits from an expenditure of $134 million.

By 2012, a similar analysis of 120 ACIAR projects estimated benefits of $2.2 billion had accrued to Australian agriculture from an expenditure of $379 million.

These benefits are realised through many pathways. There are direct productivity improvements achieved because of new production technologies, or new breeds, varieties, vaccines, trade links and industries. Benefits also accrue from:

- the management of and protection from disease and pest incursion
- increased demand in third-country markets from meeting food safety, quarantine and quality requirements
- environmental, biodiversity and sustainability improvements associated with management of natural resources
- increased trade.

PHOTO: PAUL JONES

In allocating its investments, ACIAR brings together the agricultural R&D priorities of partner countries with the needs, interests and capabilities of Australian researchers.

These interests are pursued by commissioning collaborative research between international, Australian and developing country organisations in areas where Australia has a special focus and research competence.

ACIAR also supports the International Agricultural Research Centres (IARCs), primarily those operating under the umbrella of the Consultative Group on International Agricultural Research (CGIAR), to undertake R&D of common interest to Australia and developing countries in our region.

These linkages build multilateral capacity that can exceed that of individual nations and provide opportunities to share the costs and risks of so-called 'blue-sky' projects. At present this includes Australian participation and leadership in consortia attempting a step change in the photosynthesis efficiency of rice and wheat crops.

Situated this way, ACIAR has been leveraging agricultural R&D nationally and internationally into areas of importance for Australian and partner country agriculture since 1982.

The linkages and networks are especially vital to Australian production systems given their reliance on exotic species such as wheat, barley, sheep and cattle, and the foreign genetic resources needed to ensure ongoing productivity gains.

Ultimately, that means ACIAR adds unique capacity to Australia's innovation system, providing essential support to Australian agricultural productivity, profitability, biosecurity, sustainability and resilience into the future. ■

THE DRIEST CONTINENT SEEKS TO DROUGHT-PROOF ITS FARMS

ACIAR ACTION Farming on the world's driest inhabited continent is no trivial feat. Drought is an inevitable reality across the Australian agricultural sector and it is an ever-present challenge to the scientists whose research supports these production systems. Already, Australian crop varieties are among the most water efficient, able to yield around the two-tonne-per-hectare mark even as rainfall drops below the demarcation line of a desert (200 millimetres). Even so, 'drought tolerance' is an immensely complex genetic trait and there are no easy fixes. So as droughts intensify, agricultural scientists must pursue new, more sophisticated ways to drought-proof Australian farms and do so at a time of diminishing growth in public funding of agricultural science. In this setting, ACIAR in the 2000s has been funding one of the world's best cereal drought tolerance teams to pioneer an entirely new class of traits. Led by Dr Michelle Watt of CSIRO Plant Industry, impressive gains are proving possible by selecting for deeper, more vigorous root systems, especially at the time of flowering and seed setting. Dr Watt says that soils often possess a reservoir of moisture at this time both in Australian and Indian dryland farming systems, but it is out of reach of the roots of current varieties. "Any water taken up through the roots at this time is directly used for grain production and could have a big impact on yield," she says. "We have calculated that the uptake of an extra 10 millimetres can contribute to an extra half a tonne of grain per hectare."

PHOTO: PAUL JONES

A NATURAL AT PROMOTING CAREERS IN AGRICULTURE

ACIAR ACTION Worldwide there is concern about the declining numbers of students enrolling in agriculture courses and Australia is not immune from this worrying trend. There are about 4,000 Australian jobs a year for tertiary-trained graduates in agriculture but currently universities are producing about 700. Even as science enrolments increased by 30% between 2002–10, the numbers taking up agriculture actually declined (–0.5%). The National Farmers' Federation says the situation is disappointing and recruiting young people into the sector is one of the industry's biggest challenges. Calls have abounded to better promote agriculture careers. ACIAR offers a range of scholarships and fellowships within its capacity building program. In 2013, there were 93 active postgraduate fellowships for developing-country scientists associated with ACIAR projects to study in Australia, with 38 scientists completing studies at either masters or PhD level. As they acquire new skills, this ACIAR cohort of students makes invaluable contributions to Australian agriculture. Case in point is Dr Sambasivam 'Sam' Periyannan from India. During his ACIAR-supported PhD at the University of Sydney and CSIRO, he was an integral part of the team that isolated a disease-resistance gene that stunned the world. The gene, *Sr33*, protects wheat crops from all stem rust disease races including Ug99, which is capable of devastating 90% of the world's wheat varieties. Since completing his PhD, Dr Periyannan is working at CSIRO as a postdoctoral researcher where he is now closing in on two other novel stem-rust-resistance genes as part of the Borlaug Global Rust Initiative.

PHOTO: BRAD COLLIS

Secure borders and the overseas engagements that protect agriculture

BY WARREN PAGE

A major source of benefits to Australia from ACIAR's agricultural R&D activities is in the sphere of biosecurity. Australian agriculture relies on the cultivation of a range of introduced species and while they are susceptible to diseases and pests, Australia remains free from several biological threats, such as foot and mouth disease.

Our disease-free status is important for agricultural productivity and a component of successful trade and exports. An incursion of a disease or pest could have significant economic and environmental consequences for Australia.

As international travel has become easier, the job of keeping Australia free from unwanted pests has become more demanding. Trade also creates opportunities for biological threats to spread, as does the growth of agriculture in neighbouring countries.

The Department of Agriculture leads biosecurity initiatives, providing significant protection to Australian agriculture. But ACIAR programs focus on some of these problems as well.

By doing so, ACIAR helps to give Australian scientists experience with biological threats offshore, thereby building expertise and also developing tests and vaccines while enhancing and strengthening our research systems.

Slowing and stopping the spread of biological threats within the agricultural industries across our region helps neighbouring countries and it helps Australia.

LIVESTOCK

THE ANIMAL DISEASES THAT DID NOT REACH AUSTRALIA

BY DR GIO BRAIDOTTI

There are viruses that can devastate communities not by causing illness in humans but by decimating their livestock—the chickens, ducks, pigs, sheep, goats and cattle that are needed as food, fibre or income.

Unlike non-biological hazards such as drought, viruses can mutate and exchange genetic material with other viruses, allowing them to evolve … including into forms that can infect and be transmitted among humans and even cause global pandemics.

One virus that shows a particularly high mutation rate is highly pathogenic avian influenza (HPAI) or 'bird flu', which includes the H5N1 variant that devastated poultry industries across Asia in the 2000s and showed some propensity to infect and kill humans.

The HPAI viruses do not respect national borders. Instead, protection comes from cooperation among nations, especially those along livestock trade routes, and the availability of biosecurity capacity that includes surveillance, diagnostics, vaccine development, farm hygiene techniques, quarantine and veterinary science services.

Not all developing countries affected by HPAI possess the infrastructure to respond effectively when viruses invariably mutate. Conversely, Australia possesses the technological capacity but as an island nation benefits from stopping the viruses beyond its shores.

As a result, there is a strong incentive for ACIAR to work in the area of livestock biosecurity and these projects have always had high intrinsic value to Australia.

Besides HPAI, ACIAR actively engages abroad in ways that help Australian livestock industries remain free from classical swine fever (CSF), foot and mouth disease (FMD), rabies and very virulent infectious bursal disease (vvIBD, known as gumboro in Indonesia).

These are diseases that have been endemic among Australia's closest northern neighbours. Examples include the spread of H5N1 across Indonesia and striking the island of Bali in 2003 at a time when it was still suffering from the economic downturn resulting from the bombings of the Kuta tourism precinct.

With a strong history of collaborative animal disease research in the Asia–Pacific region, ACIAR rolled out a strong response to the bird flu crisis. Those projects exploited Australia's

CONTINUED PAGE 14

PHOTO: 123RF.COM

PREVENTING RESPIRATORY DISEASES IN PIGS

ACIAR ACTION The Australian pig industry has an annual production value of $1.24 billion, with about 17% exported. However, the industry shares with the Philippines a major production constraint—respiratory disease from a variety of disease agents—that costs $30 to $100 per sow annually, according to Australian Pork Limited estimates. In the Philippines, 98 million Filipinos rely on pork as their main dietary source of protein, but respiratory disease causes about 50% of all pig mortalities. A recent outbreak in Luzon, in the Philippines, of porcine reproductive and respiratory syndrome (PRRS) virus alarmed the Australian pork industry but prompted the Philippines Government to improve biosecurity measures in collaboration with Australia through ACIAR. This included assistance to identify and close technical gaps in surveillance, develop cost-effective laboratory tests for bacterial and viral agents for respiratory diseases, implement disease management systems and develop mechanisms to communicate the results throughout the industry. The outcome is more effective surveillance and controls against respiratory diseases that strengthen the pork industries in both countries.

PHOTO: 123RF.COM

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research strengths and were primarily aimed at filling knowledge gaps so that better informed disease-control decisions could be made.

In the case of Indonesia's H5N1 crisis, the Indonesian Government sought assistance from ACIAR directly to help develop disease management capabilities. It was important to ACIAR to complement and not replicate efforts underway as part of the global effort directed at HPAI.

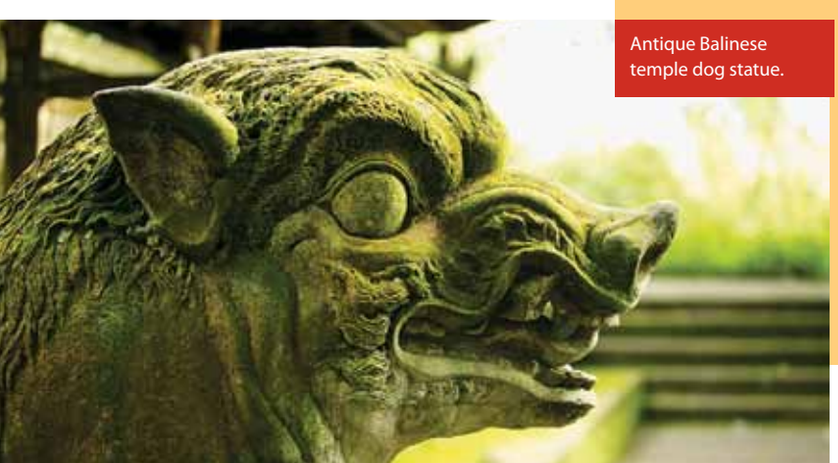
In Indonesia, projects ranged from tools to assist central, provincial and local jurisdictions to cooperate to control a range of animal diseases, through to understanding the specific role ducks play as a virus reservoir in HPAI transmission (including the identification of the most resistant duck breeds) and studies on how the virus changes in response to vaccination.

Impacts on the ground have had important and measurable effects. For example, by the time of the fourth bird flu outbreak in Bali during 2007, surveys undertaken by University of New England economist Dr Phil Simmons found that farmers were responding better, vaccinating more and implementing biosecurity measures so that the disease claimed about half the chickens it did during earlier outbreaks.

ACIAR's research activities also form part of coordinated and cooperative efforts with the Department of Agriculture and the Australian Biosecurity CRC for Emerging Infectious Disease.

Returns to Australia are large, primarily from controlling the disease at its source abroad, thereby making it less of a threat to Australia. But there is also a capacity-building aspect whereby Australian scientists become familiar with the disease, better understanding its real-world effects on-farm, in the community and across its transmission routes.

In the best possible outcome, the threat abroad abates, Australia remains disease-free and Australians remain blissfully unaware of the intense research, development and extension activities that continuously go towards maintaining desirable levels of biosecurity. ■



Antique Balinese temple dog statue.

KEEPING FLIES OFF THE FRUIT AND VEG

ACIAR ACTION Australia is largely self-sufficient in fruit and vegetables with crops worth $7.2 billion, making horticulture Australia's third-largest agricultural industry. Effective, integrated disease management and quarantine strategies are essential to this industry to minimise losses and for access to export markets. One of the most serious horticultural pests is the fruit fly. In the Asia–Pacific region, the fruit fly poses a major obstacle to establishing horticultural industries and it is an issue dealt with repeatedly by ACIAR over 30 years. Between 1984 and 2009, ACIAR invested $15.14 million (in constant 2006 Australian dollars), which has delivered biosecurity benefits worth more than $67 million to Australia and $212 million to partner countries. ACIAR also facilitated the establishment of the International Centre for Management of Pest Fruit Flies (ICMPFF). The centre is based at Griffith University and is committed to researching and implementing pest management and quarantine strategies for horticultural industries. It has its headquarters at the Nathan campus in Brisbane and a regional office hosted by the Malaysian Ministry of Agriculture in Kuala Lumpur. ICMPFF director Dr Dick Drew is a long-time ACIAR collaborator. He says that projects in countries such as Vietnam, Malaysia, Bhutan and Indonesia highlight the centre's mission to work collaboratively with the Association of Southeast Asian Nations to find practical solutions to the region's fruit fly problem.

PHOTO: 123RF.COM

Man's best friend faces rabies epidemic

Rabies is now less than 500 kilometres from Australia's shores as it continues to spread through eastern Indonesia. Between the disease front and Australia lies a large susceptible population of dogs, livestock and people.

In 2007 the virus took a step closer to Australia when it appeared on the island of Bali, apparently due to the illegal movement of infected dogs on fishing boats. The movement of vessels around eastern Indonesia, East Timor, Papua New Guinea and northern Australia will likely continue the spread of rabies in this region.

The dog-loving islanders of Bali faced their first confirmed rabies case in November 2008. Suddenly, in a community where humans and dogs lived in mutual affection and dependence, a deadly virus threatened the wellbeing of both. By May 2010, 11 people were dying every month from rabies. Over the next three years, more than 140 humans and 643 dogs died.

For ACIAR, the epidemic coincided with Australian study tours for senior Indonesian veterinarians and also training in integrated Incident Control System (ICS). A pilot ICS implementation scheduled for foot and mouth disease was reassigned to deal with the Bali rabies epidemic and funding was assigned to set up 10 ICS Rabies Control Centres.

Building on the successful establishment of rabies diagnostic capacity at the Denpasar regional veterinary laboratory (BBV) in early 2009, field staff received training in collection of dog brain samples, inexpensive field sampling kits and funds for the transport and testing of specimens at the BBV that greatly improved surveillance capacity and informed treatment options for Balinese people.

Various rabies awareness programs ran—as TV ads or CDs for schools—but it was traditional dance performances with rabies messages that produced the biggest change in people's behaviour, significantly increasing the numbers of dogs presented for rabies vaccination.

Activities culminated in a joint government-NGO mass dog rabies vaccination that covered most of Bali and resulted in a steady decline in both human and canine rabies. From the peak of 11 people a month dying from rabies in 2010, the incidence was reduced to one or zero deaths each month by December 2011 to the present.

With support, the Balinese people faced down a deadly epidemic and brought rabies to heel in just three years. In the process, they significantly reduced the reservoir of virus from which rabies could make the leap to Australia.

FORESTRY

IN DEFENCE OF AUSTRALIA'S TREES

BY DR GIO BRAIDOTTI

Australian eucalypt and acacia trees are widely grown in plantations internationally, particularly in South America and South-East Asia. It is a circumstance that brings the trees into contact with new ecologies, including new, potentially invasive pests and diseases.

Outbreaks can ensue and pose acute biosecurity threats to Australia, endangering species that are vital to the natural landscape and to tree-based industries. Examples include the gall wasps and the sap-sucking bug, which were mostly unknown in Australia before they became a problem overseas.

Conversely, Australian pests that are of little consequence in the bush—where they co-evolved with natural enemies—can cause huge problems for plantations overseas.

The threat is exacerbated by trade and the movement of people, says biological control expert Dr Simon Lawson of the Queensland Department of Agriculture, Fisheries and Forestry. "As these have increased in recent years, so too has the rate of introduction of invasive pests and pathogens to the major eucalypt plantation growing regions."

Dr Lawson was well aware of the problem but realised that the global nature of the underlying issues required a global response linked to local forestry expertise in all the affected regions.

"The speed of invasion and the lack of basic biological knowledge about the pest species were compromising efforts to coordinate and optimise biological control programs around the world," he says. "This isn't a problem you can solve in a piecemeal fashion. It involves the identification, evaluation, selection, collection and shipping of natural enemies to affected regions. That requires coordinated and cooperative responses."

Normally the complexity of these situations is a stumbling block for researchers, but failure to act comes with dire consequences. In situations like this, ACIAR comes into its own. The centre excels at brokering international R&D alliances among many research partners in addition to enabling investment in these collaborative ventures from a variety of sources.

An ACIAR initiative (FST/2011/028) was launched to improve international collaboration on invasive pests of eucalypts and one of its outputs was to scope the potential for the development of a centre for the biocontrol of eucalypt pests.

The centre could help develop much-needed tools—from tapping naturally occurring enemies of eucalypt pests for use overseas to an 'over-the-horizon' surveillance network for emerging biosecurity threats to protect Australia's planted and native forests.

The project was headed by Dr Lawson, whom ACIAR linked to collaborators in Brazil, Argentina, Uruguay, Vietnam, Laos, Indonesia, Thailand, China, Malaysia and South Africa.

"Such a centre could be supported by both government agencies and by the international eucalypt plantation industry, especially from countries with well-developed, mature plantation industries like Brazil, Argentina, Uruguay and Chile in South America, South Africa, China and European countries," Dr Lawson says. "Significant synergies and cost-savings could be achieved by such an approach."

Initially the focus would be on eucalypts, but could be expanded in the future to include acacia and areas where Australian-developed *Pinus* germplasm is grown.

The concept was presented to the Forest Health Joint Meeting, 'Pathogens, insects and their associations affecting forestry worldwide', held by the International Union of Forest Research Organisations (IUFRO) in Uruguay in November 2011. Already an informal network of researchers interested in pests of eucalypts around the world has been established.

Five broad themes for the biological control of eucalypt pests globally were developed at the meeting:

- identifying new potential biocontrol agents and wider genetic diversity in existing agents
- host specificity testing of biological control agents
- databasing (including barcoding) of agents released around the world
- enhancing information sharing and communication
- assessing the potential impact of the Convention on Biodiversity (CBD) and Access and Benefit Sharing (ABS) on biocontrol. ■

PHOTO: 123RF.COM

The myrtle rust incursion —a cautionary tale

Rob Dyson clearly recalls when the disease-causing myrtle rust fungus was first detected in Australia. Based on the central NSW coast, he has been a tea tree oil producer for more than 30 years.

Like many within the industry, he knew about the susceptibility of his tea tree plantation to the new fungal disease. That information was obtained years earlier through ACIAR research undertaken by CSIRO in Brazil's eucalypt plantations, where myrtle rust first emerged when a local fungus (guava rust) jumped species. In Brazil, it was possible to safely study the threat posed to Australian vegetation and CSIRO found the fungus had acquired the ability to infect at least 3,000 species in the myrtle family.

It is a finding that highlights the need for extra biosecurity measures, given the adoption of Australian tree varieties by forestry industries abroad.

To this day it is unknown how the fungus reached the cut-flower-growing facility in NSW where it was first detected on 23 April 2010. "There were attempts to quarantine its spread and for a while the rust didn't move," Mr Dyson says. "Now it is widespread up and down the coast, in both agriculture and forests."

Tony Larkman, industry development officer for the Australian Tea Tree Industry Association, says that growers so far have "dodged a bullet" as the rust is present at levels that are not yet economically damaging to the $21 million industry (as valued in 2010).

"That is giving us time to work with the Rural Industries Research and Development Corporation (RIRDC) to identify resistant genotypes and effective fungicide treatments," Mr Larkman says. The lemon myrtle industry has not fared as well.

Then there are additional concerns for the bush. "While I am prepared to replant with resistant tea tree varieties, I fear the impact on the species composition of natural forests into the future," Mr Dyson says.

HORTICULTURE

IN SUPPORT OF THE BANANA INDUSTRY

PHOTO: 123RF.COM

BY DR GIO BRAIDOTTI

Since 1983, ACIAR has supported more than a dozen projects on the production and processing of bananas. When ACIAR started there were just three people working on banana research in Australia. ACIAR's ongoing support has helped to lift Australia to a position of world excellence. This R&D base—particularly on disease diagnosis and the management of pests and diseases—has strengthened Australia's crop protection capability.

This is reflected in the fact that Australia is now recognised as one of the world leaders in research on *Fusarium* wilt disease and on *Fusarium* wilt pathogen diversity. Such advanced capability allowed Australian researchers to identify that the Honduras-bred cultivar Goldfinger is resistant to all races of *Fusarium* and to black sigatoka disease.

Australia now also hosts one of only two indexing laboratories in the world, located at the Indooroopilly Research Centre of the Queensland Department of Agriculture, Fisheries and Forestry.

The laboratory underpins the ongoing monitoring and replacement program that protects Australia from black sigatoka disease. So too the development of diagnostic tests that enable researchers to identify bunchy top disease before its symptoms are expressed in the field. This test was an important step towards providing disease-free material to farmers.

The benefits to banana growers of biosecurity R&D can be considerable. An insect pest such as banana skipper can destroy, on average, 60% of the leaves of infested banana plants. It reached Papua New Guinea in 1983, where it spread at a rate of 500 kilometres per year and could have reached Australia by 1995.

Instead, the pest was controlled in Papua New Guinea by 1990 through the use of a biological control agent—a small parasite—identified with the support of ACIAR.

The estimated benefits to Papua New Guinea are $202 million, with 43,000 people lifted above the poverty line through averted income losses and cost increases, according to 2003 estimates.

Benefits to Australia through reduced risk of entry of the insect are estimated at $223 million. The benefit–cost ratio of this research was independently assessed to be 607:1, from an outlay of $2.1 million.

ACIAR research also delivered benefits to postharvest handling technologies. Examples include the better use of fungicides to control stem end rot and of ethylene to control ripening of bananas under modified-atmosphere storage.

The benefits from this research have been estimated to exceed $50 million across several countries, with the Australian share estimated at $6 million.

ACIAR administers the Australian Government contribution to the International Network for Improvement of Banana and Plantain (INIBAP), worth $200,000 per year, and it too conducts global banana research relevant to Australia, Asia and the Pacific. ■

MITE PESTS OF HONEY BEES IN THE ASIA–PACIFIC REGION

ACIAR ACTION Mite pests of bees are one of the major production constraints facing the apiary industry throughout the world—except in Australia, the only country free from these pests. The maintenance of effective quarantine strategies is a major aim for Australia, a task assisted by about 15 years of investment in mite research by ACIAR. The outcomes of the research are a good example of the mutual benefits inherent in ACIAR's collaborative research model—in this case, important advances in understanding of mite–bee relationships. These, in turn, have enabled the development of some simple control measures for smallholder beekeepers and important new strategies to significantly improve quarantine procedures for Australia. Included is the discovery that it is possible to eliminate *Varroa* mites from Indonesia given sufficient institutional development. Further, the scientific work underlying these projects has been groundbreaking, leading to one of the most cited scientific papers to come from CSIRO Entomology and to substantially improved understanding of the mites worldwide. Benefits have been estimated at $72.6 million in total (2007 value) by the Centre for International Economics, with $161 million accruing to Australia.

PHOTO: 123RF.COM

FISHERIES

INVASION BY ALIEN AIR-BREATHING PREDATORS

BY PETER GEHRKE

Air-breathing fish such as striped snakehead, walking catfish and climbing perch have a distinct advantage when it comes to invading new territory: they can survive out of water for days.

It is a trait that entices fishers to transport live fish between villages and islands. But even without this assistance, the air-breathing fish are known to waddle crudely between water systems in the manner of intrepid, semi-amphibious missing links.

In their native range—which covers Southern and South-East Asia from China to Pakistan—they are an important food fish of considerable economic importance. But since their introduction in Indonesia, the species have proven voracious predators with a natural talent for spreading southward.

They entered Papua New Guinea's Western Province from Indonesia during the 1980s and rapidly established wild populations in the Fly River system and surrounding catchments, where they are proving difficult to control and appear to be spreading. All three species were recorded in the Kikkori River, 150 kilometres east of the Fly, and unconfirmed reports also place climbing perch in the Port Moresby region.

From here, they are moving towards northern Australia, where they pose a threat to native species such as barramundi. Already climbing perch is established on the Australian islands of Saibai and Boigu in Torres Strait.

To better grasp the biosecurity implications of this alien invasion, ACIAR commissioned the Snowy Mountains Engineering Corporation (SMEC) to undertake a scoping study and assess the policy implications for Papua New Guinea.

ARRESTING AN ALIEN INVASION

Snakeheads are the most voracious of the three species, able to grow up to 1 metre long. They are expected to affect recruitment of species such as barramundi by preying on juveniles in nursery wetlands.

Climbing perch are smaller, growing to about 25 centimetres, and use strong fin spines and flexible sub-opercula to pull themselves over land. They feed on aquatic plants, shrimps and small fish. Predatory Australian species such as large fork-tailed catfish and barramundi have been found dead with climbing perch lodged in their throats.

Walking catfish grow to about 50 centimetres and have an omnivorous diet, feeding on insects and insect larvae, earthworms, shells, shrimps, small fish, aquatic plants and detritus.

If these species establish populations in Australia, potential effects on aquatic ecosystems and fisheries are likely to be significant through predation, competition for food, habitat damage, disease and parasites.

In addition to effects on freshwater species, commercial species that spend time in estuaries and coastal wetlands could also be affected.

For the time being, a strong public awareness campaign by the Australian Quarantine and Inspection Service appears to be preventing their spread further south from Saibai and Boigu islands.

Beside fishers, these predators have been found to have other means of invading Australia at their disposal. They can migrate along river channels, through coastal waters in low-salinity river plumes, overland between rivers and wetlands or aquaculture ponds, and through drainage channels alongside road networks.

Dead pelicans with climbing perch in their throats have been found on other islands, suggesting that birds may also be a vector for transport.

Available information suggests that climbing perch are spreading most rapidly, especially into Torres Strait, but it is highly likely that striped snakehead and walking catfish will follow within the next 10 years.

Options in Australia to reduce the potential impact on local environments and fisheries have been identified. These include working with Papua New Guinea to contain populations and prevent their further spread, including across Torres Strait.

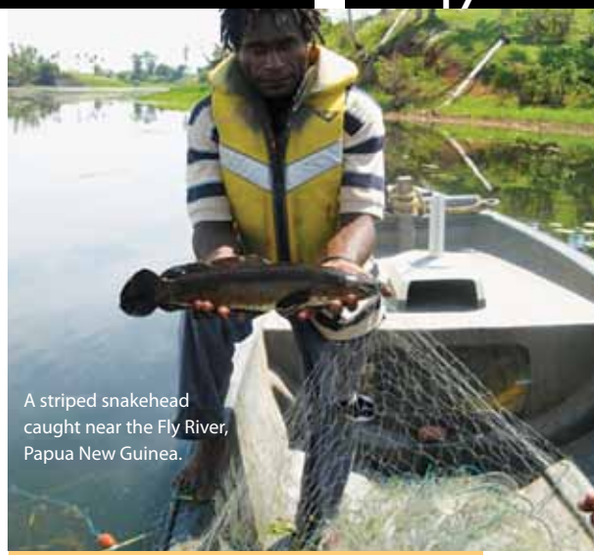
Besides community education to reduce the incidence of human-assisted spread, a need was also identified to develop the capability to eradicate populations where it is feasible and practical to do so, especially at the island level.

While trade in invasive fish in Australia is prohibited under existing legislation, continued vigilance to prevent illegal importation of live fish is recommended.

Following the completion of the project, a workshop was held in Brisbane to raise awareness of the threats posed by these invasive species. Outcomes include a risk assessment of existing policies in Australia, identification of linkages between government agencies, assessment of communication processes, and identification of knowledge gaps on potential rates of spread, biology and impacts of invasive species, and control options.

The project was conducted with strong assistance from Boga Figa, formerly with James Cook University, and Jacob Wani, National Fisheries Authority of Papua New Guinea. ■

More information: Peter Gehrke, peter.gehrke@smec.com, www.smec.com



A striped snakehead caught near the Fly River, Papua New Guinea.

Achievements over the years

- **A rapid diagnostic test for foot and mouth disease developed in an ACIAR collaboration with Thailand allows the confirmation of the disease in a matter of hours, saving vital time in containing a disease outbreak.**
- **The development of a reliable and accurate diagnostic test for bluetongue disease in cattle and sheep facilitated a change in Chinese quarantine policy to allow the importation of Australian live cattle. This ACIAR project provided the basis of a mutually acceptable quarantine procedure between Australia and China relating to the export of live cattle.**
- **In Australia, ACIAR projects underpinned methods now used for active animal health surveillance in Queensland's extensive beef industry sector. This includes the adoption by the Australian Quarantine and Inspection Service of a method to identify and diagnose *Trypanosoma evansi*, a protozoan that can infect a wide range of animals.**
- **Graziers in Australia's extensive cattle grazing areas benefited from the application of tick fever tests derived from ACIAR projects that aid decision-making regarding whether expenditure on vaccines is warranted.**
- **ACIAR research contributed to the effective papaya fruit fly eradication campaign in northern Queensland. Research on fruit flies in the South Pacific region contributed towards the development of regional quarantine strategies to manage fruit fly problems within neighbouring countries.**

INNOVATION AND ENTREPRENEURS

The innovation made through ACIAR projects does not flow one way—experience gained overseas can stand Australian agricultural businesses and entrepreneurs in good stead.

BY DR WENDY HENDERSON AND DR GIO BRAIDOTTI

Global demand for forestry and fisheries resources has been growing over the past five decades. Demand for forest products (production and consumption of sawn wood) has risen from 358 million tonnes in 1965 to 417 million tonnes in 2005, and is projected to rise by another 100 million tonnes by 2020 (*State of the World's Forests*, 2009, Food and Agriculture Organization). The trend in fish consumption is also rising, growing at a rate of 3.6% per year since 1961 (World Health Organization).

With growth in demand comes opportunities for those able to supply value chains. The challenge is balancing growing demand with sustainable supply. Both the forest and fisheries sectors are vulnerable to over-harvesting, resulting in depletion of the natural resource base. Technical innovations that link sustainable approaches to long-term profitability can mobilise new investments and regional development opportunities.

ACIAR's sandalwood projects are a case in point. Sandalwood is one of the world's most valuable forest products prized for its aromatic oil that is also used in a wide range of products ranging from incense-joss sticks and furniture to perfumes and pharmaceuticals. Its value, however, has led to over-harvesting of wild stock.

Australia has moved towards establishing sandalwood plantations from high-oil-yielding stock. It is a new industry that uses silvicultural techniques largely developed through ACIAR forestry projects in the 1980s and 1990s.

The native sandalwood species growing in Western Australia (*Santalum spicatum*) supplies about half of the world's legal sandalwood. A newer industry based on exotic Indian sandalwood (*S. album*) is now also emerging, concentrated largely in the fertile lands of the Ord River Irrigation Area (ORIA) in northern Western Australia.

This species produces a much higher oil content than its counterpart and is worth substantially more per tonne. Much of the *S. album* in its home countries has been over-exploited, so overseas supplies are dwindling, leaving Australia in a strong position to reap the benefits from its new plantations.

Growing sandalwood on a commercial scale is a fine art. Sandalwood is a hemi-parasitic plant (like mistletoe), taking nutrients from a host plant to use for its own growth through specialised root structures called haustoria. While many plant species, usually legumes, can be potential hosts, commercial-scale production requires identifying hosts best suited to nurturing sandalwood.

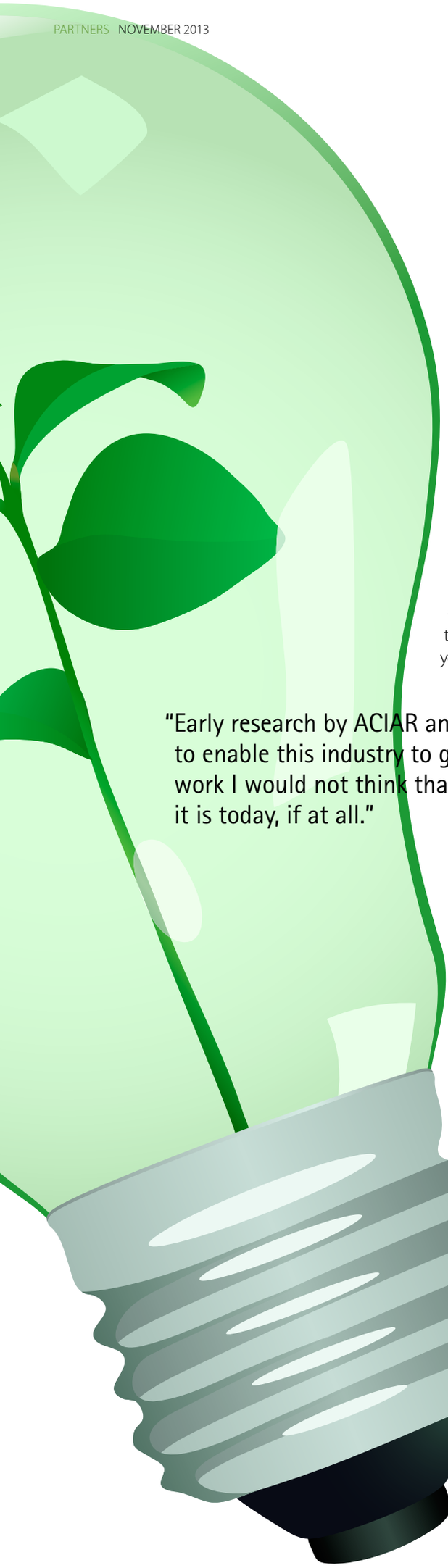
Further complicating matters, several different hosts are needed during sandalwood's cultivation, depending on its life stage. In early seedling stages in the nursery, a 'pot host' is needed followed by at least one short-term intermediate host, which needs to be grown adjacent to the young sandalwood plants. Finally a long-term, larger host is needed to supply nutrients to more mature sandalwood in the plantation.

The best host for each stage is a different species with different properties, and needs to be chosen specifically to optimise its interaction with the sandalwood.

ACIAR funded sandalwood research with the WA Department of Conservation and Land Management (CALM) from 1987–95 in Indonesia and Australia. Dr Frank McKinnell, who led the research, says it formed the foundations for the current Indian sandalwood industry here.

"We were looking at the potential for a fast-grown plantation crop, so we knew there would have to be more than one host plant over the rotation," Dr McKinnell says. "But we had no information on what hosts might be suitable nor what was the most efficient way to raise seedlings as a commercial operation.

"The work carried out under the ACIAR projects developed reliable nursery techniques for mass production of high-quality seedlings, as well as demonstrating the practicability and value of several second-stage and third-stage host plants. Therefore, it laid the basis of the



current sandalwood industry in the ORIA and elsewhere in northern Australia."

Indian sandalwood has evolved into a large-scale commercial industry in Australia. One of the major companies in this space is Tropical Forestry Services (TFS). It manages the largest amount of Indian sandalwood under plantation in the world, with 7,600 hectares of *S. album* in Western Australia, Northern Territory and Queensland. The company is due to complete its first major harvest in 2014, when trees reach the preferred harvesting age of 15 years.

"Early research by ACIAR and others provided the impetus to enable this industry to get started. Without this initial work I would not think that this industry would be where it is today, if at all."

– ANDREW BROWN

"Australia has the space, water, climate and technology to successfully grow and value-add to Indian sandalwood, so TFS believes there is a valuable opportunity in growing Indian sandalwood," says Andrew Brown from TFS.

"Early research by ACIAR and others provided the impetus to enable this industry to get started. Without this initial work I would not think that this industry would be where it is today, if at all."

An independent impact assessment of the ACIAR research has estimated large benefits for Australia—an estimated $936 million (in 2012 Australian dollars) return on the first harvest which is 100 times the initial investment by ACIAR and others in the plantation-related research. Returns of up to $150,000 per tonne are being achieved.

Benefits also flow to the local Indigenous community in the form of employment. TFS has an Aboriginal liaison officer in its Kununurra office who works to facilitate Indigenous employment opportunities within the organisation.

Private and public research on *S. album* continues, ever on the lookout for better trees, better hosts, and more efficient growing methods. Current ACIAR-funded research on sandalwood in Australia is focusing on another high-quality species that occurs in Cape York (*S. lanceolatum*).

This work involves partnerships with two Indigenous communities, the Queensland Department of Agriculture, Fisheries and Forestry, and James Cook University. It is showing promising potential for another new branch of sandalwood production in the far north.

Aquaculture also faces opportunities for technical innovation—particularly in hatchery technology—in the face of growing demand for seafood and sustainability concerns over wild harvests. It is an area where Australia receives many mutual benefits from collaborative projects, particularly with South-East Asian countries such as Vietnam.

ACIAR projects provide scientists with the opportunity to look at aquaculture technology for species that are new to Australia. Edible clams, pipis and sea ranching of sandfish are just some of the projects that improve opportunities for farmers but also aid efforts to restock wild populations.

Linkages formed between countries help expand production and trade activities, a process that can create new opportunities for Australian business investment. An example is the welcome mat that authorities extended to the Australian aquaculture industry to take up business opportunities in Vietnam.

Dr Le Thanh Luu, director of the National Marine Broodstock Centre in Vietnam, has told the Australian aquaculture industry that opportunities in Vietnam extend beyond aquaculture to the spin-off and supporting industries, such as facilities for intensive culture, feed mills for marine species, production of probiotics for environmental treatment and production of vaccines for the improvement of aquatic animal health.

"While Vietnam has excellent professional and personal relationships with Australian scientists, there are also investment opportunities for the Australian business community," he says. ■

Thinking outside the box

ACIAR contributions cut across all sectors, from fisheries on the high seas to aquaculture, cropping, livestock and forestry.

AQUACULTURE

BARRAMUNDI WITH A SIDE SERVE OF LOTUS FLOWER

BY DR GIO BRAIDOTTI

Native water plants such as the lotus, *Nelumbo nucifera*, are proving proficient at remediating waste aquaculture water for recycling back into ponds, including Queensland's inland barramundi ponds, which constitute the state's largest inland aquaculture industry.

The bioremediation potential of plants native to Australia and Papua New Guinea (PNG) was described in an ACIAR project and addressed an issue identified by the Australian Barramundi Farmers Association as a major priority area in need of innovation.

The beauty of the ACIAR solution is that the plants themselves possess commercial value. The lotus, for instance, has nutritional, medicinal and ornamental value. Thus new horticulture industries can be developed as a by-product of sustainably recycling aquaculture pond water.

This work was a continuation of the ACIAR-funded scoping study 'Development of capacity for aquaculture of indigenous fish species in Papua New Guinea', which sought to assist inland aquaculture development in PNG and Australia in an environmentally and culturally sensitive way. This included targeting herbivorous native fish species for aquaculture to avoid the need for expensive feeds.

However, water availability and the quality of the discharge water proved a limiting factor to aquaculture development. Barramundi were then used as the culture species in trials of bioremediation using aquatic plants undertaken by the Queensland Department of Agriculture, Fisheries and Forestry (QDAFF), led by Dr Evizel Seymour.

The aquatic plants tested are common to both PNG and Australia—duckweed (*Spirodela punctata* and *Wolffia angusta*) and lotus (*N. nucifera*). Water savings were achieved with both.

While duckweed produced water savings of 22%, lotus proved much more effective, producing astonishing savings of 62%. The plants were also proficient at removing waste nutrients, including 45% of ammonia nitrogen, 35% of total nitrogen, 19% of total phosphate and 32% of all suspended solids.

Importantly, fish growth rates were not affected by water re-use.

"Reducing environmental impacts and increasing ecological sustainability are important elements of aquaculture in Queensland," Dr Seymour says.

"Water re-use and water discharge quality to the natural environment are factors currently concerning the aquaculture industry, especially inland barramundi farming."

The Great Barrier Reef Marine Park Authority is increasingly scrutinising farming practices as part of efforts to protect the quality of river water that flows onto the reef from land-based activities.

Environmental requirements in Queensland are becoming more stringent and farmers are required to move towards zero discharge to the environment under both state and federal policy and legislation.

For the trials, native lotus seed was sourced from Ross River in Townsville, Queensland, and duckweed from a barramundi farmer's ponds. Both have potential for commercialisation. For example, uses for duckweed as an animal feed are well documented.

PHOTO: 123RF.COM

Bio-Tech Waste Management Pty Ltd (1998) trialled duckweed as a feed for chickens, ducks, sheep, fish and abalone. Additionally, numerous studies promote duckweed as a low-cost feed for tilapia, but none have actually compared the costs of duckweed production to other feed sources.

In developing countries where feed ingredients may be unobtainable and labour is the only commodity, duckweed may be a viable feed source to provide protein. This may be relevant to highland Papua New Guinea, where protein supplies are short.

The lotus has been consumed in its various processed forms throughout Asia and quality product from Australia was expected to capture the interest of Asian markets. All parts of the lotus are used in Asian medicine; the leaves and flowers contain various aromatic substances and the rhizomes and seeds are high in calcium and kalium (potassium).

"The leaves, flowers, seeds and the parts of the root system known as rhizomes can be used in food and medicine and, of course, lotus is a popular ornamental plant," Dr Seymour says. ■

ACIAR project: FIS/2004/065

FISHERIES

SEAFOOD LOVERS HELP CHAMPION TUNA'S FUTURE

BY DR GIO BRAIDOTTI

Australia and Indonesia share migratory stocks of yellowfin and bigeye tuna, but information gaps surrounding these species and their associated fisheries are hampering sustainable fisheries management.

Wild yellowfin tuna are among the largest tuna species, reaching weights of about 180 kilograms. They often travel in schools with similarly sized companions, other tuna species or dolphins, whales and whale sharks. Unlike most fish, tuna are warm blooded and their warm muscles make them incredibly strong swimmers, reaching speeds of up to 80 kilometres per hour.

Indonesia's take of tuna and tuna-like species is highly significant on the world scale, accounting for 15% of the total catch in the Indian Ocean—in excess of 800,000 tonnes in 2008. The export value of Indonesia's tuna was about US$250 million (A$263 million) .

Over the past 20 years or more, the number and size of target tuna species in individual vessel catches has been declining. Fleets now need to operate further from traditional fishing grounds to achieve profitable catches.

The commercial longline fishery alone had about 1,100 vessels active in 2010. There is also concern about the rising number of fish aggregating devices (FADs) in Indonesian waters, which attract fish such as yellowfin tuna, skipjack tuna and Spanish mackerel as they migrate through the Indo–Pacific. The devices are increasing fishing pressure on stocks of juvenile tuna and the likelihood of unsustainable fishing practices.

In a previous ACIAR project that reviewed Indonesia's Indian Ocean tuna fisheries, both countries agreed that the best approach to increased cooperation was through institution building, technical cooperation, training, skill sharing and developing capacity by improving practices and procedures for data management and reporting.

If sustainability of tuna fisheries as a whole can be achieved, the potential benefits are enormous. The current project seeking to achieve this goal is headed by Dr Craig Proctor, of CSIRO Marine and Atmospheric Research.

The project involves a population structure study of yellowfin and bigeye tuna species, which will help determine how to best assess and manage fisheries harvesting these stocks.

This includes investigating current deployment of FADs and their implications for the fisheries. The project is scheduled to run until 2016. ■

ACIAR project: FIS/2009/059

FORESTRY

SEEING THE FOREST AND THE TREES

BY DR WENDY HENDERSON

ACIAR funds a suite of forestry research projects in South-East Asia aimed at increasing the value of plantation-grown trees to smallholder growers and their communities. The projects are led by Dr Henri Bailleres from the Queensland Department of Agriculture, Fisheries and Forestry, and Professor Barbara Ozarska from the University of Melbourne.

Challenges faced by South-East Asian growers include legal requirements for certifying that timber has come from legal sources, improving competitiveness in international markets, and the lack of income over the years trees need to mature combined with the market reality that older trees are more valuable.

Much ACIAR-funded research is addressing the question of whether timber from short-rotation plantations—5–10 years old rather than decades old—can be used for high-value wood products such as furniture and quality building materials.

Short-rotation trees are not harvested in Australia, but Dr Bailleres says they could be, with great gains for the industry.

The potential benefits to Australia are many, especially since investment in the Australian forestry sector has severely declined over the years. As a consequence, innovations successfully developed and trialled overseas are being welcomed by growers in Australia.

The researchers too are benefiting, not only from the increased knowledge base but also from extended research networks.

Dr Bailleres says that much of the generic research on silviculture, processing, gluing and veneer products is mutually beneficial. Valuable insights have also been gained on fast-growing plantations and lean manufacturing—how to get 'more from less'.

The research has demonstrated effective and affordable ways to grow and process young trees and reduce wastage. Professor Ozarska says the amount of wastage can be drastically reduced using innovative approaches, including peeling logs for veneer products and making valued composite materials from offcuts.

ACIAR's whole-of-value-chain approach has also highlighted inefficiencies in the industry that result from players working as separate entities.

PHOTO: 123RF.COM

Dr Bailleres and colleagues recently discussed the ACIAR forestry research with HQPlantations in the industry. As a direct result, the company has changed its tree-growing practices and the products it is aiming to produce.

Growers are now more confident in the potential of new markets for small logs. ACIAR research projects demonstrate that processing technologies and markets are evolving faster than the trees grow. This is a game-changer for growers and foresters.

Dr Bailleres says ACIAR's research will go a long way towards improving Australia's forestry future if growers, processors and manufacturers agree to adopt new and more adapted ways of doing things. ■

LIVESTOCK

CLIMATE CHANGE EXACERBATES THE LIVESTOCK FEED GAP

PHOTO: 123RF.COM

BY DR GIO BRAIDOTTI

A livestock project in South Africa is providing ACIAR with opportunities to help adapt agriculture to a drying climate across southern Australia, particularly the south-west, which has experienced a 15% reduction in rainfall since the mid-1970s.

The idea is to mitigate feed gaps experienced by livestock through the use of new forage legumes and their nitrogen-fixing root-nodule bacteria (or rhizobia). This includes bringing into production legumes native to dry regions in Australia and South Africa, including legumes collected from the fringes of the Kalahari Desert.

The project has been underway since 2006 in partnership with South Africa's Eastern Cape Province. The project is led by Professor John Howieson, an internationally recognised expert and Foundation Director of the Centre for Rhizobium Studies at Murdoch University in Western Australia.

Professor Howieson specialises in root-nodule bacteria as commercial inoculants for agricultural legumes and in developing and domesticating new legumes for sustainable agriculture, including the commercially released 'Eliza' serradella.

He says that legumes and rhizobia can be thought of as nitrogen factories that are currently producing nitrogen worth in excess of $2 billion to the Australian economy. The ACIAR project is attempting to extend these benefits by collecting native legumes and rhizobia, testing them as pasture and identifying combinations that can return to previously productive, now-abandoned arable land.

With funding from ACIAR and assistance from collaborators in South Africa, the Centre for Rhizobium Studies has been domesticating shrubby perennial legumes collected from the fynbos (the natural shrubland) of the Western Cape. Lebeckia is the most advanced example of this.

"This perennial legume, collected from South Africa, is adapted to very infertile sandy soils, and has now been grazed successfully through the summer of 2011, and we are moving to development of three major evaluation sites in the wheatbelt of Western Australia," Professor Howieson says.

"Rhizobial ecology studies have identified and overcome challenges to developing a rhizobial inoculant for lebeckia. I expect the species and its unique nodule bacteria to now become a commercial reality and anticipate commercialisation in 2014–15."

Australia too boasts a large array of native legume species. Work at the centre has been redressing a lack of information about the relationships between these native legumes and their root-nodule bacterial symbionts, particularly in Western Australia, and studying the microbial diversity of native legume-nodulating bacteria.

"The centre has conducted several studies to better understand the microbial diversity of native legume-nodulating bacteria," Professor Howieson says.

"One approach has been to identify root-nodule bacteria with the potential for agricultural applications as inoculants on existing legume crops. Another is assessing the use of indigenous root-nodule bacteria with provenance legumes to rehabilitate long-term degraded sites in dryland areas. Members of the centre have also studied the diversity of root-nodule bacteria populations on the legumes of the state's south west."

He also applies this expertise to ACIAR's SIMLESA project (Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa) and he is on the steering committee for a US$20 million (A$21 million) project—'N2Africa: Putting nitrogen fixation to work for smallholder farmers in Africa'—funded by the Bill and Melinda Gates Foundation. ■

ACIAR project: LPS/2004/022

NEWS IN BRIEF

Aquatic farming

In 2012 there were about 20 active projects in ACIAR's fisheries portfolio: 70% dealing with aquaculture and the remainder covering wild harvests. Key concerns relate to the responsible management of wild-capture fisheries, better use of existing harvests, the development of productive and sustainable aquatic farming systems, innovative resource management and market-related risks. The program is committed to active engagement with relevant local communities, resource managers, extension agencies and policy makers in project design and execution to promote informed local ownership and effective engagement. The geographic focus is South-East Asia, Papua New Guinea and Pacific Island countries.

THE VIRTUAL FARM

ACIAR ACTION Increasingly, Australian scientists use computer simulation technology to help analyse complex agricultural systems. Central to such efforts is an internationally recognised software package developed with ACIAR support—the Agricultural Production Systems Simulator (APSIM). It contains a suite of modules that allow advanced simulation of agricultural systems and cover a range of plant, animal, soil, climate and management interactions. Through the APSIM Initiative, the package undergoes continual development, with new capability regularly added. ACIAR's role in its development dates to a research project between Australia and Kenya from 1984–93. At that time, ACIAR supported CSIRO efforts to build simulation capability, particularly of dryland farming systems, which resulted in technology that contributed to the development of APSIM. Since 1995, ACIAR has supported further development of this technology through additional projects in India and Africa. Besides helping to improve farm, land and water management, APSIM has found applications internationally, including at the International Maize and Wheat Improvement Center and the International Crops Research Institute for the Semi-Arid Tropics, which have applied it to improve farming systems in India and southern Africa.

PHOTO: 123RF.COM

'Live rock' has a large and growing market as an ornamental must-have addition to saltwater aquariums.

OF GIANT CLAMS AND LIVE ROCK: ORNAMENTAL AQUACULTURE

ACIAR activities in the Pacific region sometimes resonate well with the needs, interests and agribusiness opportunities available among Indigenous communities in northern Australia.

BY DR GIO BRAIDOTTI

On the Pacific island of Tonga it is the cultivation of organisms for the marine aquarium trade that is fomenting an economically viable aquaculture industry. While trade in ornamental organisms may seem trivial, the aquaculture facility has important conservation trade-offs, both in terms of replacing unsustainable wild harvests and in restocking depleted reefs.

Additionally, the ACIAR project has sparked interest among Indigenous communities in Australia where 'mariculture' is proving a low-impact industry that resonates well with traditional ways of interacting with the natural world.

In view of broad social, cultural, environmental and economic benefits, ACIAR has played pivotal roles in providing the research needed to develop mariculture expertise and capacity both in Tonga and among Australian Indigenous communities.

Research activities have been mainly based at Tonga's Fisheries Mariculture Facility (FMC). The facility was originally established with Japanese assistance to supply tuna bait to commercial fishers. ACIAR's engagement began after the facility was badly damaged by a tropical cyclone in the 1980s.

The ACIAR project made it possible to refurbish the facility to meet standards for the cultivation of giant clam (*Tridacnidae*) for a large and growing marine aquarium trade. Subsequently in the 1990s, Japanese assistance made it possible to improve the facility's seawater flow-through system to allow the cultivation of species for resources enhancement, including commercial top and green turban snails.

The opportunity to expand further into the cultivation of aquarium organisms came in 2009 when ACIAR joined with the Secretariat of the Pacific Community (SPC) on a project to cultivate corals and 'live rock'—the misleading name given to the aragonite skeleton of dead corals, which can be colonised and encrusted by colourful coralline algae and other unusual micro and macro marine life.

The result is a low-impact, low-maintenance industry. The marine animals being cultivated require sunlight and no additional feeding. The industry sits well with the 2008 decision taken by Tonga to ban wild harvest and export of live rock.

Bart Penny of the Kimberley TAFE's Broome Aquaculture Centre says it was a combination of these properties that made live rock mariculture appealing to various Indigenous Australians. "A live rock aquaculture industry fits perfectly with the Indigenous community's local understanding of marine systems and their important cultural activities," he says.

As a result, the Tonga experience became grist for the establishment of a course on live-rock aquaculture—the first of its kind in Australia—that extended the Pacific experience gained through the ACIAR project to potential Indigenous enterprises.

ACIAR supported James Cook University aquaculturists Scott Mactier and Cathy Hair to provide the course and pass on some of the lessons learnt about live rock cultivation in Tonga.

The course covered work practices associated with producing and exporting cultured live rock, including manufacturing the artificial rock base, preparing species for colonisation, harvest techniques, packing for export and basic trade operations.

A cross section of the Indigenous community attended, including Aboriginal students and potential business people from the mid and north regions of Western Australia and the Northern Territory. Lectures and practical sessions were conducted at the One Arm Point Hatchery.

Following the course, Indigenous communities in northern Western Australia have taken up the technology and are trialling opportunities to develop a new mariculture industry.

The ACIAR team members provided trouble-shooting exercises, an understanding of the features of good artificial rocks and the tools to develop rocks from materials in their own areas, along with skills and tips on improving their operations.

"There is also a network established of experts who are available to contact if problems arise with their commercial operations in the future," Cathy Hair says.

"Given the physical and social similarities of Indigenous Australian aquaculture and that in the Pacific Islands, the knowledge gained through the course will be invaluable to the development of the industry in Australia." ■

ACIAR project: FIS/2006/138

NEWS IN BRIEF

Reseeding the wild

Trochus shell is highly sought after for buttons and costume jewellery. Australia, Indonesia and the Pacific islands supply about 7,000 tonnes of shell annually and there is concern about depletion of the fishery. An ACIAR project investigated the prospect of using cultured trochus to reseed depleted reefs in this region and developed a simplified method of inducing spawning in trochus. In Australia, a pilot hatchery to produce juvenile trochus for the reseeding research was constructed at One Arm Point in 1999. The hatchery was funded by ACIAR, Fisheries WA, Bardi Aborigines Association and the Aboriginal and Torres Strait Islander Commission (ATSIC). Today the hatchery is both a tourist destination and mariculture centre that provides livelihoods to the local Bardi-Jaawa people. In recent years up to 15 tonnes of trochus have been exported to Europe, particularly to Italy's fashion industry. At $9 per kilogram the export trade provides substantial returns, with all the profit earned going back into the local community.

ACIAR project: FIS/2001/085

Food choices

With access to nutritious leafy vegetables limited in the Indigenous communities of northern Australia, Samoa, Solomon Islands and Fiji, the health impacts have become a concern to ACIAR. A project is underway to identify leafy vegetables with the potential to improve human nutrition, alongside activities to understand and document the reasons for food acceptability among these communities. ACIAR's Pacific Agribusiness Research for Development Initiative (PARDI) is on board too, examining commercial factors such as market development and loss of nutritional value in postharvest handling.

ACIAR project: PC/2010/063

Say it with flowers

World trade in ornamental flowers, foliage and live plants continues to increase and there are recognised market opportunities for the supply of novel products by Indigenous communities based on the rich biodiversity of the Pacific and Australian region. Scoping studies by ACIAR have identified opportunities for improving Indigenous livelihoods through the use of novel, native floriculture activities and enterprises.

ACIAR project: HORT/2008/011

Overseas aid helps Australia conserve soil and water

The impact on farmers from unsustainable land and water management practices are rapidly felt in the more marginal landscapes and among those with tighter profit margins. Climate variation and change exacerbate existing pressures. Research advances that improve sustainability and resilience become increasingly essential to farmers' livelihoods.

Agriculture is particularly vulnerable to the vagaries of seasonal and climatic variation. Research has worked to find the means to manage climatic extremes—such as drought-tolerance traits in crops—and to better predict seasonal variations—such as long-term forecasting.

For farmers, managing the risk involved is a frustrating part of the job. For smallholder farmers struggling to achieve food security and earn an income to escape poverty, often farming marginal or low-yielding land, even small shocks can cause major crop losses.

ACIAR's projects help lay the groundwork, both to mitigate such shocks and to help farmers adapt to changes in climate. They do this by promoting the development of sustainable, market-linked farming systems that help promote food security and income for poor farmers.

A critical component of this approach is managing water resources, both for irrigated and rain-fed farming systems. ACIAR's water management projects link on-farm approaches to water management and savings to system-wide approaches.

Water is of critical importance to agriculture around the world and it is the leading factor limiting productivity today and into the future. This is also the case in many Australian agricultural systems.

Efficient water use and sustainable management of water resources are two key areas of ACIAR activity that deliver important sustainability benefits for agriculture, food security and farm profitability.

It was estimated in 2006 that 1 trillion (1,000 billion) litres of water were saved in Australia per year as a flow-on benefit from just four projects conducted by Australia's overseas aid program, with the innovations capable of delivering an

PHOTO: 123RF.COM

additional 2 trillion litres per year. This is equivalent to filling Sydney Harbour six times or filling three million Olympic-size swimming pools.

The four projects that delivered these savings were all run in partnership with Asian countries facing similar challenges to the river basins and irrigation areas most important to Australian agriculture.

The projects tackled diverse challenges, from salinity from rising watertables caused by irrigation through to trialling water re-use systems that maximise production opportunities from limited water resources.

These projects sit within a broader program

THE FOUR PROJECTS THAT DELIVERED THE ONE-TRILLION-LITRE WATER SAVINGS

MORE RICE WITH LESS WATER—THE MURRUMBIDGEE AND COLEAMBALLY IRRIGATION AREAS

This ACIAR project was conducted in partnership with the Yellow River Basin in China. The ability to generate three sets of data, based on similar climatic and soil conditions, provided scientists with greater certainty about how much water was being lost during its transport from rivers to farms and where the losses were occurring. The project also identified additional possible gains. Project outcomes included:

- **converting flood and furrow irrigation to sprinkler and trickle irrigation**
- **matching water savings investments with higher-value cropping systems**
- **matching different crop varieties to soil, water and groundwater conditions**
- **reducing delivery-system leakages through channel lining, piping and replacing outdated equipment.**

IMPROVING IRRIGATION EFFICIENCY—THE ORD RIVER IRRIGATION AREA

High irrigation water use and leakages from Lake Kununurra and its irrigation channels has led to rapidly rising watertables in the Ord River Irrigation Area (ORIA). As a result, waterlogging and salinisation threaten large sections. CSIRO scientists working on an ACIAR-funded project in China also sought to better understand the movement, distribution and quality of water. By lowering the water levels of Lake Kununurra they demonstrated that water savings of up to 5,000 litres a year could be achieved through reduced leakage.

The increased subsurface drainage in the Packsaddle Plain helped to lower the watertable by 1–2 metres for the first time since irrigation began in the early 1960s. This is helping to prevent salinity and waterlogging in the Packsaddle Plain, the most affected area in the ORIA. Modelling of irrigation management strategies across the whole area identified savings of up to 30% of irrigation water simply by modifying irrigation schedules—savings that can be realised without productivity losses. Recent estimates found that about 20% of growers had implemented improved irrigation practices, reducing their water use by about 20%.

SUSTAINABLE RE-USE OF SALINE DRAINAGE WATER—THE MURRAY–DARLING BASIN

This project investigated options for the sustainable re-use of drainage water from agricultural areas in Pakistan and Australia. The system that was tested—serial biological concentration (SBC)—re-uses drainage effluent, cascading it through a series of crops that reduces its volume while increasing its salinity, with final containment of a small volume of highly saline effluent in an evaporation basin. The process maximises productive use of water, extends the lifespan of irrigation areas through salinity management, and increases productivity of limited water resources.

Piloting of the SBC system in Pakistan helped finetune the technology for deployment in Australia. In areas of the Murray–Darling Basin, 60,000 hectares of land have been identified as highly suitable for the use of SBC, allowing for water savings of 120,000–180,000 million litres of saline recharge, depending on the crops sown and water allocations.

CONTROLLED TRAFFIC FARMING—THE DARLING DOWNS AND NORTHERN NEW SOUTH WALES

This project identified improvements in soil management practices for rainfed cropping environments that can increase water storage in soils. ACIAR-commissioned research in China demonstrated the importance of restricting tractors and other heavy vehicles to fixed, permanent lanes, with crops grown on undisturbed zones between these traffic lanes. This prevents soil compaction and the break down of soil structure that reduces rainwater infiltration, water-holding capacity and the availability of this water to crops. Leaving crop residues on the soil surface further reduces water loss in run-off and evaporation. It also has the potential to affect return flows to either groundwater or surface water systems. Another benefit is the ability of traffic lanes to better support traffic in wetter conditions, allowing farmers to plant sooner after rainfall. When conventional tillage is replaced by controlled traffic and zero tillage, the amount of rainfall available for crop growth increases by 32%. There are also fuel savings of 4–8 litres per hectare due to the reduced level of traffic across paddocks. Benefits to Australia were estimated to be worth $145.4 million in 2006.

in which, over 25 years, ACIAR has invested in 98 collaborative research projects to improve water productivity. Gains were made through improved irrigation schemes, better catchment management and more efficient water allocation systems that also reduced losses. The results are helping farmers to use their water more efficiently.

The objective is to achieve 'real' water savings. This means using less water or getting more production out of the same amount of water—'more crop per drop'.

For example, one ACIAR project focused on growing more rice with less water. Researchers studied water-saving options in three irrigation schemes in China and Australia. Water savings were achieved at the system level and on-farm. This meant irrigators could use limited water resources productively and reduce the amount of water lost through system inefficiencies.

Another project carried out in China's Ningxia province helped improve irrigation management in Australia's Ord River Irrigation Scheme. CSIRO scientists and their Chinese counterparts from the Chinese Academy of Sciences were able to improve water management, reduce losses and better use groundwater to reduce salinity build-up.

These are issues of vital importance in Australia and many of ACIAR's partner countries. In Pakistan, India and China the available water resources no longer satisfy population demands. Even in higher rainfall countries such as Vietnam and the Philippines, water availability and competing demands create pressures on water usage and quality.

Agriculture, particularly irrigated production systems, is the major user of fresh water in the world. By 2025 current population growth rates are projected to double the use of fresh water. Feeding the world will require an additional 5,600 trillion litres of water for agricultural, industrial and household use.

More sustainable, productive and profitable ways of managing water, such as those already generated within ACIAR programs, will be vital to providing the world's future food, feed and fibre. ■

SOIL-PROFILING AID TO FARMERS

ACIAR ACTION ACIAR collaborators developed a simple Soil Constraints and Management Package (SCAMP) that uses properties of soil—be it collected samples or soil in the field—to identify constraints and indicate appropriate management strategies. It was developed in an ACIAR project to help sustainably manage upland soils in Vietnam. The inclusion of a soil/water partitioning model into SCAMP expanded its capabilities, allowing it to trace the major pathway of water movement—run-off, ponding, drainage—for any soil, based on its drainage and permeability ratings. This information has been used to map the major pathways of water movement in soils of the wet tropical coast of Queensland. Furthermore, by linking to information about the timing and placement method of fertiliser application, the package can also assess the risk of nutrients moving into environmentally sensitive areas. Following voluntary training, Queensland sugarcane farmers have adopted site-specific soil management tools to help attain compliance with environmental regulatory regimes such as the *Great Barrier Reef Protection Amendment Act 2009*, which seeks to avoid damage from fertiliser run-off into rivers that drain into the Great Barrier Reef.

PHOTO: 123RF.COM

MAPPING PRODUCTION CAPABILITY

ACIAR ACTION The suitability of land for growing crops such as legumes and field crops can be easily assessed as a result of ACIAR research on crop diversification in Cambodia and Australia. In Western Australia's southern cropping region, this has resulted in the development of maps that plot the land's capability for field pea, chickpea, lentil and faba bean crops. The maps identified areas not previously targeted for pulse production. The Department of Agriculture and Food, WA, has adopted the maps to help target critical areas of its pulse breeding R&D. The method used to generate the mapping capability is also being used to predict the effects of climate change on major grain commodities. Furthermore, the Grains Research and Development Corporation is adopting and applying the method to break crops such as oilseeds, pulses, oats and lupins that are used in rotation with and benefit production of key crops such as wheat and barley.

PHOTO: iSTOCKPHOTO.COM

NEWS IN BRIEF

Peanuts

Peanut varieties with improved drought tolerance and increased water-use efficiency were developed through ACIAR-funded research led by the Queensland Department of Agriculture, Fisheries and Forestry in the decade to 2003. The improved germplasm was made available to breeders in Australia and India to lift production in drought-prone areas.
ACIAR project: CS1/1997/114

Rice

The adoption of permanent raised beds in rice-based cropping can improve returns on every 1,000 litres of water used from $96 to $136 per litre, and thus a significant saving. Project beneficiaries included rice irrigators in south-west New South Wales. The project was led by CSIRO and the NSW Department of Primary Industries and jointly funded by ACIAR, the Grains Research and Development Corporation and the Rural Industries Research and Development Corporation.
ACIAR project: LWR/2000/089

Citrus

Victorian citrus orchards achieved water savings of 25% through improved management of irrigation schemes, which was developed in an ACIAR project involving the Victorian Department of Primary Industries and the China Agricultural University in Beijing. Impacts included reduced water wastage and matching the amount of water applied and the time of application to meet specific crop needs.
ACIAR project: SWL/1990/048

The international nature of germplasm enhancement

Underlying the performance of elite crop varieties is an international network matching plant genetic traits to the challenges of farming in dry, hot, frosty, salty or other problematic growing conditions. Through this network, which includes a range of gene banks, opportunities to improve crops flow to researchers and breeders around the world. ACIAR works to facilitate the flow of material, which is especially important to Australia, where cropping industries are unusually dependent on exotic, imported species.

BY DR GIO BRAIDOTTI

In 1999 wheat crops in Uganda failed when a devastating disease long considered under control—stem rust—re-emerged in a more virulent form, which was to become known as Ug99. The breakdown of wheat's immunity alarmed the world as the fungal disease inevitably spread along well-worn routes—to Kenya, Ethiopia, Sudan and Yemen.

The cause was the breakdown of the genetically based resistance built into wheat varieties in the 1950s—traits that were a cornerstone of the Green Revolution, protecting 90% of the world's wheat varieties and 20% of the world's total calorie intake.

But in Uganda the stem rust fungus re-jigged its DNA, trying out new genetic possibilities, and found a way to break down wheat's in-built resistance. The resistance breakdown occurred at a time of declining interest and investment in agricultural science in the developed world.

It was Nobel laureate Norman Borlaug, nearing the end of his life, who raised the alarm and philanthropist Bill Gates who provided the funds to launch a response in the form of the Borlaug Global Rust Initiative (BGRI).

The BGRI is a research network that makes the best use of existing resources, funding researchers with specialist rust expertise wherever they exist. It developed facilities to screen the susceptibility of the world's wheat varieties and to screen for resistant germplasm in Kenya, where Ug99 is prevalent. Breeders at the International Maize and Wheat Improvement Center (CIMMYT) then played a pivotal role, releasing Ug99-resistant wheat cultivars to affected nations funded by donors that included ACIAR.

However, breeders know that inevitably the stem rust fungus will evolve. The genetic recoding will continue to erode away any new sources of resistance in wheat as part of a perpetual 'arms race' between fungi virulence and the immunity that breeders build into wheat.

Throughout the Ug99 response, Australia was the global 'black sheep'. First, Australia's problems with rust disease are so pervasive and potentially devastating that rust has long been a research priority and it received additional funding from ACIAR and the Grains Research and Development Corporation (GRDC) to deal with Ug99.

Second, the stem rust resistance built into Australian varieties often differed from the rest of the world (due to considerations for grain quality), with breeders preferring resistance traits (such as *Sr2*) that retained wheat's effectiveness against Ug99.

Third, rust researchers at the University of Sydney Plant Breeding Institute (PBI) in Cobbity and CSIRO Plant Industry are looking for a way off the rust merry-go-round by taking rust resistance to a new, more durable level.

A crucial stepping stone towards this important objective involves isolating rust resistance genes and decoding the mechanism of action at the molecular level.

That goal was achieved in 2013 when a team led by Dr Evans Lagudah at CSIRO Plant Industry announced the isolation of *Sr33*—a stem rust resistance gene targeted because of its unusual ability to defend against all stem rust races tested, including Ug99. *Sr33* can interact synergistically with other resistance genes (such as *Sr2*) to further raise the overall level of protection available to a wheat crop.

The importance of biodiversity

Like many plant genes of agronomic importance, *Sr33* does not originate from the genome of domesticated plants. Rather it comes from a wild relative of wheat—a line of goatgrass (*Aegilops tauschii*) collected in Iran. It is a classic example that highlights the importance of collecting, conserving, sharing and exploiting the world's crop genetic resources and of organisations, such as ACIAR, that promote these ideals.

Dr Tony Gregson, an Australian farmer and former chairman of Bioversity International, says ACIAR's influence played an important role in developments such as the establishment of the Svalbard Global Seed Vault and the International Treaty on Plant Genetic Resources for Food and Agriculture. The treaty, which was ratified by Australia, implemented a multilateral system of access and benefit-sharing of genetic resources for 64 of the most important food and forage crops.

Important techniques to exploit these resources have also been developed with ACIAR assistance. This includes FIGS (Focused Identification of Germplasm Strategy), a technique that exploits information about the seasonal agro-climatic conditions where seed is collected to better select material likely to contain important traits. This includes the frost tolerance recently identified in field peas by Australian breeders from material collected in China by Dr Bob Redden while on an ACIAR project.

PHOTO: BRAD COLLIS

Sambasivam ('Sam') Periyannan and parents Kuppusamy Periyannan and Subhulakshmi Periyannan.

THE GENE THAT MADE A DIFFERENCE

When the call to action against Ug99 was issued, it is unlikely that even Norman Borlaug could have anticipated how far and wide the message would resonate.

In the home of the Green Revolution, a small 1.5-hectare tropical cropping farm on the banks of the Cauvery River in India would prove a leading player in the battle against Ug99.

Kuppusamy Periyannan and his wife, Subhulakshmi, are innovators in their farming community. While they have never participated in an ACIAR project, they understand something that developed nations can easily ignore—the vital role science plays in agricultural productivity to benefit the poor and their rural communities.

It is an outlook that caused the Periyannans to highly value an opportunity they were denied—an education. They valued it enough to take out loans on their farm to educate their children but insisted that one, Sambasivam ('Sam') Periyannan, bypass popular courses in engineering or information technology (IT) in favour of agricultural science.

Sam Periyannan was subsequently responsible for cloning *Sr33* while completing his PhD at CSIRO Plant Industry in Canberra, supported in part by an ACIAR scholarship.

"At the moment there is an IT boom in India and not many parents like their children to get into agricultural science," Dr Periyannan says.

"They see there are opportunities after studying IT. But my parents were different. My father especially pointed me to agricultural science and it was the science's links to farming that pushed me to try and excel at research."

A plant pathologist by training, Dr Periyannan completed his PhD with assistance from ACIAR in 2011. He has chosen to stay at CSIRO as a postdoctoral research fellow to continue his work isolating two more novel stem rust resistance genes (*Sr45* and *Sr22*).

For CSIRO, the isolation of *Sr33* is a long-awaited innovation that radically changes the rules for breeders. Dr Lagudah says that it makes it possible to make informed, knowledge-based decisions as to which genes to combine to best thwart rust pathogens and obtain the most durable forms of rust resistance.

"We can even pre-combine genes and insert them—like a cassette of genes—into one site of the wheat genome, clearing the way for breeders to focus their crosses on combining beneficial yield and quality traits. The cassette could even include tolerance genes to stresses like salinity. "

It is a vision shared by ACIAR and the GRDC, which have both funded the CSIRO team, well before the existence of the BGRI.

"That support allowed us to gain the attention of the Gates Foundation, which then provided additional resources that accelerated progress towards identifying individual resistance genes," Dr Lagudah says.

"Along the way we proved that it is possible to do sophisticated molecular work with wheat despite its large, cumbersome genome. In turn, that means we can attract more young scientists to risk working with wheat. So there is a spectrum of benefits from this kind of work: from research right through to the delivery of real world impacts."

For Dr Periyannan, there is an additional benefit, one arising from ACIAR's unique position as both an R&D funder and a research for development agency.

"I'm so happy and proud that part of the work I do goes back to the farm—including smallholders and subsistence farmers in developing countries—through ACIAR's work in India, Bangladesh and other countries," he says.

"My own roots are with smallholder farmers

THE INDIA CONNECTION

ACIAR ACTION Australia and India share similar agricultural and natural resource management problems for key commodity crops such as wheat, resulting in researchable issues of mutual relevance. ACIAR has supported a program of collaborative agricultural research with India since 1983. Most ACIAR programs in India consist of bilateral projects, in which Australian research organisations collaborate with one or more Indian research institutions, such as the Indian Council of Agricultural Research (ICAR). The arrangement has benefits for both partners allowing, for instance, Australian pre-breeders access to otherwise restricted germplasm or to field-trial sites especially suited to research on water-restricted dryland farming. As Indian R&D capacity has grown over the years the country has opted, like many developing countries, to invest heavily in its agricultural research sector. This has resulted in projects where the Indian research partner is directly funded by India and working with ACIAR-funded Australian teams on major productivity challenges. ACIAR's strategy for 2011–16 focuses on joint partnerships with increasing co-investment by ICAR and other partners focusing on four 'clusters'.

PHOTO: PETER CORNISH

Rice commonly fails in the terraced uplands, as it has here in 2005. Participatory research developed aerobic rice culture to address this problem and evaluated alternative kharif crops.

1. Research to improve agricultural water management, particularly in rainfed areas.
2. Sustainable intensification of zero-tillage cropping systems that incorporate pulses.
3. Faster breeding of crops to target, in the case of wheat, product quality aligned with emerging demands for better quality chapattis, bread and biscuits from India's 200-million-strong middle class.
4. Assisting policy development in relation to agricultural adjustment, water management and climate change.

The vital link to international research centres

While award-winning research is underway in Australia to provide wheat with durable, broad-spectrum resistance to rust disease, it is breeders at CIMMYT who exploited their gene bank and breeding capability to release resistant wheat cultivars to nations devastated by Ug99.

Australian taxpayers help fund CIMMYT and other International Agricultural Research Centres (IARCs) through funds administered and managed by ACIAR. It is an investment pattern with a long-standing record of achievements and one that was more recently adopted by the Bill and Melinda Gates Foundation.

"Investing in agricultural development is one of the most effective investments we can make," Bill Gates said at the opening of a new $25 million Biocentre, built at CIMMYT's headquarters with philanthropic dollars from the Carlos Slim Foundation and ongoing support for research activities from the Gates Foundation.

"It allows farming communities to become self-sufficient and prosperous by growing and selling more of what they produce. When you ask where the best work is done for poor farmers, the answer is here, at CIMMYT. Bringing together the collective experience of our respective organisations, we can promote innovation to transform the lives of farmers in Mexico and around the world."

Australia has a system in place to fast track access to this germplasm. The system, established by the Grains Research and Development Corporation, allows elite breeding material to be received annually from CIMMYT and evaluated under Australian growing conditions.

Initially established around wheat germplasm, the program has been so well received that it was subsequently expanded to include durum wheat, barley and chickpea germplasm from ICARDA and ICRISAT, including both elite material and landraces.

and something that really interests me now is to get involved in an ACIAR project and to further my ties with ACIAR, perhaps by helping to train scientists from India, Nepal or Bangladesh, introducing them to gene cloning technology and DNA markers and how they can be applied to help farmers."

For the *Sr33* discovery and many other contributions, Dr Lagudah and Dr Periyannan were both listed among researchers awarded the BGRI Gene Stewardship prize during the 2013 BGRI Technical Workshop in New Delhi, India. The award is given annually to scientists who contribute to responsible management of genetic resources of wheat.

The Australian researchers were selected for outstanding achievements in 15 areas, including developing programs for stacking resistance genes, creating molecular markers, strategic planning for durable, long-lasting, disease-resistant wheat varieties, highly effective training programs, willingness to share genetic resources, and strong efforts to clone resistance genes.

The winning researchers are based at three institutions—CSIRO Plant Industry, the University of Sydney and the University of Adelaide—which collectively form the Australian Cereal Rust Control team.

"The nominating credentials of each institution were so strong that the selection committee couldn't pick one," said Sarah Evanega, adjunct professor of plant breeding at Cornell University, where the BGRI is administered. "Their spirit of collaboration was the inspiration for combining the nominations into one award.

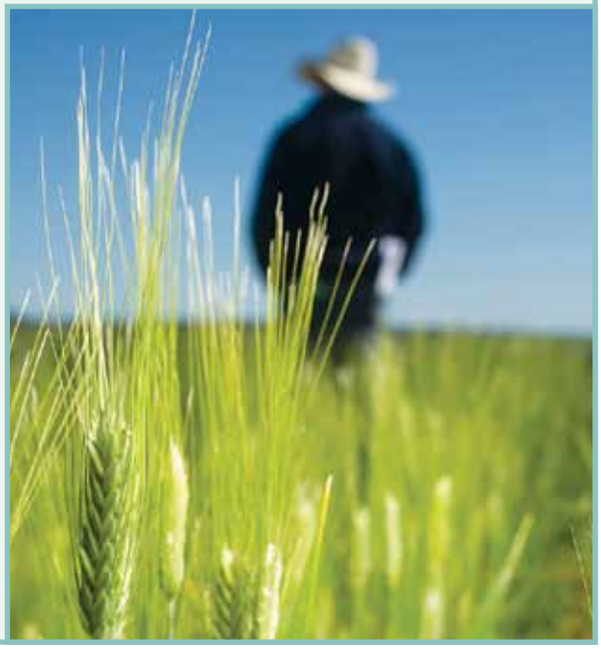
"So much great work is being done at these Australian institutions. Their expertise, their collaborative spirit and their recognition of the importance of developing durably resistant varieties serve as an inspiration for rust scientists all over the world. With this award, we gratefully recognise the efforts of the Australian Cereal Rust Control Team." ■

ACIAR project: CIM/2007/084 and 064

SHARED GERMPLASM: A PILLAR OF AUSTRALIA'S GRAIN INDUSTRY

ACIAR ACTION No less than 98% of the Australian wheatbelt is sown to varieties with genetic material derived from the genebank and breeding programs of the International Maize and Wheat Improvement Center (CIMMYT), one of the International Agricultural Research Centres (IARCs) operating to sustain global food security. The influx of CIMMYT germplasm into Australian wheat has lifted yields by as much as 10.5% in Queensland's tropical cropping region and by an average of 4.6% across Australia. By the end of 2003, an estimated 193 Australian wheat varieties were found to incorporate CIMMYT genetics. But it is not just wheat that benefits. There are two other IARCs of particular importance to all phases of a typical Australian crop rotation—which might include wheat, barley, canola, lentils, faba beans and chickpeas. These are the International Center for Agricultural Research in the Dry Areas (ICARDA), and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). ICRISAT adds an estimated $131 million in value for sorghum to Australian farms. Underscoring this value is the goodwill brokered by ACIAR on Australia's behalf.

PHOTO: PAUL JONES



RESEARCH PARTNERSHIP BUILDS ECONOMIC COOPERATION

The impacts achievable through collaborative research-for-development activities in the agricultural sector are capable of opening doors that bring people, and countries, together.

BY DR GIO BRAIDOTTI

Indonesia is a significant economic and regional partner for Australia. Two-way trade in goods and services reached $14.8 billion in 2011, making Indonesia our 12th largest trading partner and 11th largest export market.

Austrade estimates that there are more than 400 Australian companies operating in Indonesia across the mining, agriculture, construction, infrastructure, finance, healthcare, transport, and food and beverage sectors. Australian investment in Indonesia was worth an estimated $5.4 billion in 2011.

Since 2010, Indonesia and Australia have been cooperating on an agreement to strengthen and expand trade, investment and economic cooperation through IA-CEPA—the Indonesia–Australia Comprehensive Economic Partnership Agreement.

The aim is to bring the region's two largest economies closer together and will form a key part of Australia's regional and economic integration as part of Asia.

To support the negotiations, the Australian Government has established a technical assistance and economic cooperation facility to fund activities to be jointly agreed between Australia and Indonesia. These activities include pilot projects, information sharing, technical assistance and support for capacity building and policy research.

As part of that facility Indonesia requested assistance through ACIAR to establish pilot research on improving cattle breeding. That research has led to a joint project, supported by industry and governments in both countries, on scaling out past research findings.

BEEF PILOT PROJECT

Following extensive consultations initiated in 2010, a beef pilot project to improve Indonesia's cattle breeding performance was conceived—'Strengthening village-based Brahman cattle production systems in Indonesia'.

This is the first project under the IA-CEPA technical assistance facility and responds to the high priority the Indonesian Government accords to strengthening Indonesia's domestic smallholder beef sector.

The project draws on ACIAR activities from the past decade in which Indonesian and Australian researchers developed an integrated village management system (IVMS) for beef production. With the participation of more than 2,000 farmers in Nusa Tenggara Barat, the project showed that the productivity of Bali cattle systems can be doubled with simple management improvements.

Additionally, research with farmers in Nusa Tenggara Timur found that simple management changes can also reduce calf mortality from over 30% to less than 2%. These outcomes demonstrated the possibility of at least doubling the outputs and incomes of smallholder beef producers in eastern Indonesia. But it is not just the smallholder beef sector that has received Australian support.

In recent years, a close relationship has developed between northern Australian cattle producers and the Indonesian livestock industry, with trade worth more than $300 million in 2010. Since the beginning of this feeder trade and the development of Indonesia's feedlot sector in the early 1990s, there has been substantial technical transfer from the Australian industry.

Meat and Livestock Australia (which represents livestock producers) and LiveCorp (representing livestock exporters) work together to deliver in-market programs in Indonesia through the Live Export Program. This

PHOTO: 123RF.COM

technical support is focused on improving the performance of Australian cattle in Indonesia, including assistance to breeding programs conducted in feedlots.

The new pilot project is expanding the partnership, including the application of IVMS, to Brahman cattle in feedlot out-grower breeding systems. The idea is to test whether similar improvements can be obtained with Brahman cattle as were obtained with the Bali cattle system. Brahman cattle were selected for the project because of their faster growth rate and higher feed conversion compared with local Indonesian breeds.

The gains possible are multi-faceted. The pilot project offers opportunities to improve the productivity and husbandry of the local herd, increase calf output and the number of young Brahman cattle being fattened in village production systems in East Java and Sumatra.

In turn, smallholder farmers gain opportunities for selling cattle through both local marketing chains and as feeder cattle to commercial feedlots. Then there are opportunities to provide training and engage with smallholders, Indonesian livestock institutions and agricultural scientists.

This pilot project brings Australian and Indonesian producers, researchers and government officials closer together in the promotion of increased domestic cattle production and, ultimately, increased beef supply for the Indonesian market. The relationship with Australian industry will also enhance Indonesia's food security, which will become increasingly important as Indonesia's economy continues to grow and demand for beef is expected to increase significantly.

As that occurs, Australia, as a close neighbour with longstanding natural supply relationships, can continue to be an important partner with Indonesia as its growing beef demand is met through both an increase in local production and continued supplies of imported cattle and beef.

The three-year pilot project has broad-based private and public sector stakeholder support in both Indonesia and Australia. It was launched in April 2011 and is jointly funded by Meat and Livestock Australia, LiveCorp and the Australian Government.

It also highlights the power of agricultural R&D to build inter-governmental relationships and create linkages that build regional stability and promote understanding and cooperation. The value of these outputs can be described as 'scientific diplomacy'.

There are also substantial in-kind contributions from key Indonesian institutions—the Indonesian Centre for Animal Research and Development (ICATAD), the Indonesian Feedlotters Association (GAPPSI), the Beef Cattle Research Institute (BCRI) and the Assessment Institute for Agricultural Technologies of South Sumatra. ■

Aid recipient becomes donor within tripartite agreement

ACIAR has, for the first time, contracted a foreign university to manage a project in another region as part of a third-country deal expected to advance relations in South-East Asia.

Under an agreement brokered between ACIAR and Mataram University on Lombok Island, Indonesian researchers are conducting a two-year program to improve management of Bali cattle in East Timor.

Former East Timorese President Jose Ramos Horta noted the importance of educating the country's agricultural scientists to reduce reliance on foreign expertise.

"The next step in that process is the signing of the first trilateral aid initiative between Timor Leste, Australia and Indonesia," he said. "We have requested this cooperation as it helps build stronger ties with our closest neighbours and allows Timor Leste to benefit from Indonesian, as well as Australian, expertise.

"It is important in marking the next phase in the transition from subsistence agriculture to food security. Australia's role in this transition has been a small, strategic and consistent factor in the growth of our young nation."

ACIAR has led Australian engagement on food security since 2000, with the first research efforts taking place in the shadow of independence. The program since that time has evolved and helped build East Timor's capacity to the point where a new phase in research is needed.

"We wanted to build a livestock research program in East Timor and the East Timorese were keen to develop linkages with Indonesia, so we recognised this was an opportunity to put legs under the desire of both countries to strengthen their ties," says Dr Peter Horne, ACIAR's research program manager for livestock production systems and principal regional coordinator for Indonesia, East Timor and the Philippines.

"With Australia as third-party broker, the project will create a stronger trilateral relationship."

The two-year initiative also allows an ACIAR aid recipient to use its extra expertise and capacity as a research-for-development donor. If successful, Dr Horne says there are several opportunities for cross-border research collaboration using the same model.

East Timor sought the assistance after witnessing the impact of ACIAR activities in eastern Indonesia through the development of the integrated village management system (IVMS). The East Timor Ministry of Agriculture wants to see these strategies adapted to East Timor. Currently farmers have limited capacity to optimise the use of existing land and feed resources and as a result, livestock's contribution to GDP in East Timor has reached only 4.5%.

The tripartite agreement between East Timor, Indonesia and Australia amounts to the latest example of ACIAR's 'scientific diplomacy', in which the use of scientific collaborations among nations helps to address shared food security and trade problems in ways that build constructive international partnerships.

Relationships among all three partner countries have matured and grown with East Timor, and today opportunities exist to build new relationships that allow the region to mutually engage to produce a better future.

Proof positive—Australia still doing well by doing good

The benefits to Australia of investing in agricultural research and food security internationally are under review by the Crawford Fund. Here the head of the Crawford Fund's task force, the Hon. Neil Andrew, reports on key findings.


Neil Andrew

I firmly believe that Australian investment in international agricultural research helps ensure food security and farm productivity, for this country and for the world.

It leads to increased food and incomes for hungry and poor people in developing countries, who mostly live in rural areas. By improving their farming methods and skills, Australia is also supporting regional economic growth and peace. An upcoming study by a Crawford Fund task force, which I have the honour to lead, will consider benefits accruing to Australia and developing countries from our aid program.

While international agricultural research in general, and ACIAR's program in particular, should be aimed primarily at improving economic welfare in the developing countries, it is in the nature of new knowledge in agriculture—drawing on the skills and expertise of Australian researchers—that it can serve the interests of Australian producers as well.

Our study will show convincingly that it does.

Together with Margaret Reid AO, Dr Tony Gregson AM and Dr Denis Blight AO I had the pleasure of calling on Australia's Foreign Minister Julie Bishop recently and was pleased to find her sympathetic to our findings and supportive of the work of ACIAR.

STUDY PUBLICATION

I am pleased that publication of our study has been preceded by this issue of ACIAR's *Partners* magazine, which has also focused on benefits to Australia. It is hardly surprising that the two documents, albeit prepared separately, have reached similar conclusions.

There are, however, important distinctions between the two. While this commendable magazine provides examples of ACIAR's work and partnerships benefiting Australia, our report is the result of a process that commenced in March 2013. It involved national consultations, comments on a draft report and a discussion paper, as well as a commissioned meta-review of published analyses of costs and benefits to Australia.

SUPPORTING AUSTRALIAN FARMERS

Our report also points to ways that ACIAR's great work can further support Australian farmers, with a range of recommendations that I expect *Partners* readers will find of interest.

Of particular relevance to this issue of *Partners*, our commissioned high-level review demonstrated an impressive return on investment of between 50:1 and 70:1 by ACIAR and research partners in Australia and developing countries. This return:

- came from a sample of just 10% of ACIAR's total bilateral research program;
- greatly exceeds the total investment in ACIAR-led bilateral research to date; and
- most of the return results from increased farm incomes in developing countries, although it also led to advances in the productivity of Australian agriculture.

Like this magazine, our report has numerous examples of benefits and I raise just a few here.

Australian grain growers benefit financially every year by around 10 times the value of our annual investment in international agricultural research.

They achieve higher yields and/or have lower costs through using new seed resources ('germplasm') that we receive from the Consultative Group on International Agricultural Research Centres, particularly the International Maize and Wheat Improvement Center, the International Crops Research Institute for the Semi-arid Tropics and the International Center for Agricultural Research in the Dry Areas, supported by ACIAR, the Grains Research and Development Corporation and other Australian research groups that appreciate the benefit they receive through such support.

The Global Crop Diversity Trust, the World Vegetable Center, the Centre for Agricultural Bioscience International and other international centres also share their knowledge and resources with Australia.

In the protection of orchard and field crops, through work by ACIAR (and partners), Australia now:

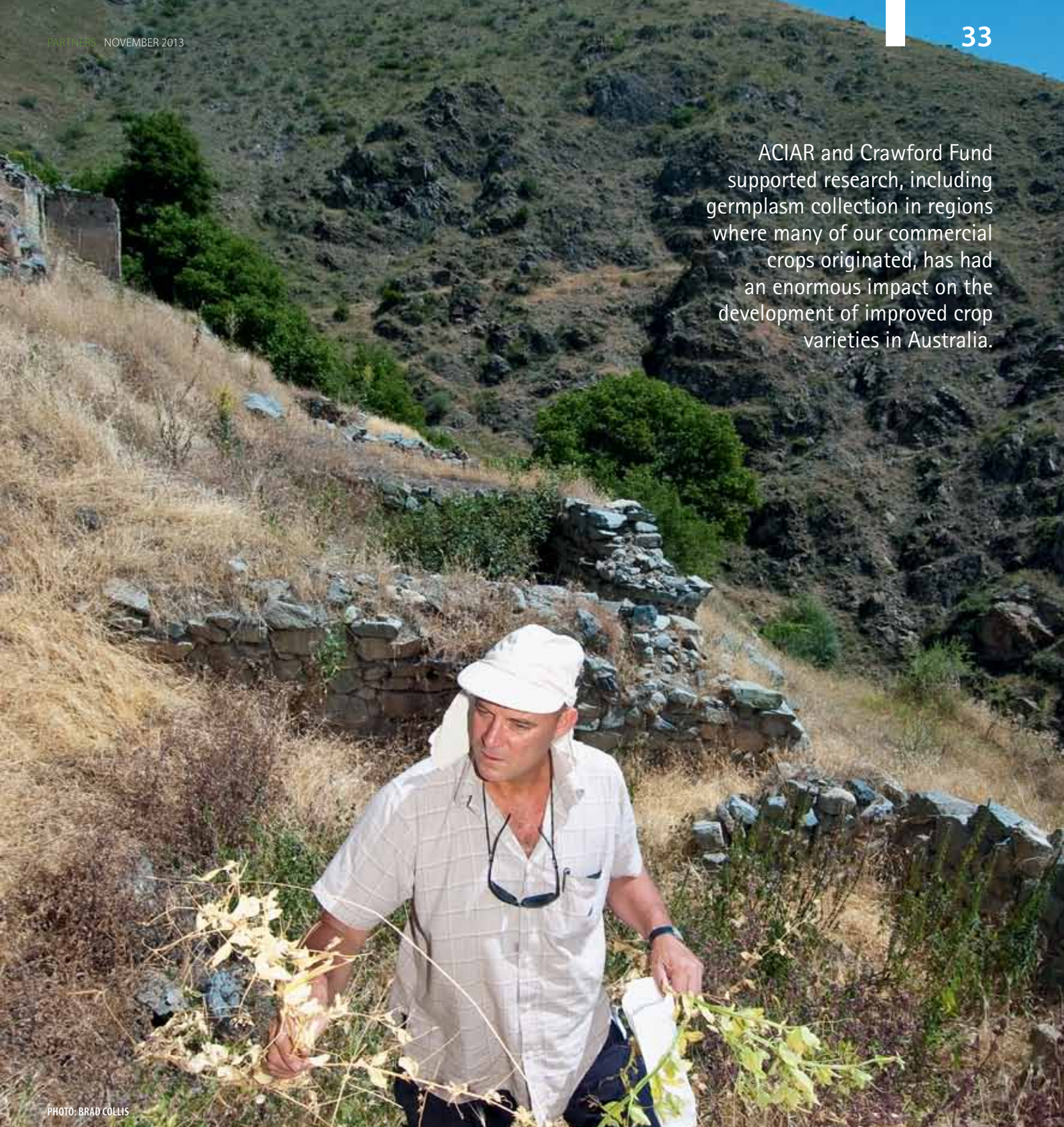
- is prepared against some potential invading mite pests of honey bees (CSIRO) which would threaten pollination; and
- understands control of fruit fly pests, including species entering Australia (Griffith University) and those formerly preventing our growers' access to the Japanese mango market (Queensland Government).

As an orchardist I confess to a parochial interest in a portion of ACIAR's work. Consequently, I was particularly interested to learn of ACIAR's work, supported by the Crawford Fund in a related master class, on citrus greening, a disease that if it were to enter Australia could destroy much of our citrus plantings.

FOOD SECURITY

It is imperative to food security that researchers, the world over, are abreast of the rapid changes and possible breakthroughs in modern agricultural science. Developing-country postgraduate students and scientists sponsored to visit Australia engage in research here. Both ACIAR and the Crawford Fund play roles in this regard. Australian researchers work abroad gaining experience and capacity, which yield unquantified benefits to Australia. These include:

- fresh thinking on Australian agricultural issues;



ACIAR and Crawford Fund supported research, including germplasm collection in regions where many of our commercial crops originated, has had an enormous impact on the development of improved crop varieties in Australia.

PHOTO: BRAD COLLIS

- new scientific tools and insights in developing countries that can also apply in Australia;
- opportunities to understand and prevent threatening biosecurity risks; and
- high credibility for Australia in international scientific forums and peer-group meetings, and among internationally respected colleagues.

The aim of aid-supported agricultural research must always be to increase global food security and reduce poverty by enhancing agricultural productivity and by increasing international trade. This research can also enhance the potential for Australian agricultural production, research capabilities and biosecurity.

It was a great pleasure for me, as a former Speaker of the House of Representatives, chair of the Crawford Fund Board and commissioner of ACIAR, to serve on the task force and to see ACIAR sustained through the change of government so that it can continue its good work for farmers in the developing countries and in Australia. ■

More information: Copies of the Crawford Fund's task force report will be available shortly on the fund's website (www.crawfordfund.org) or by contacting the office on 02 6188 4370.

"I wish to make special note of the impact of the work carried out by ACIAR, which is held up internationally as an innovative example of support to agricultural science for development that pays high returns and benefits to poor farmers and consumers in developing countries and also Australia."

—Dr Derek Byerlee, co-author, World Bank's World Development Report 2008: Agriculture for Development.

"One area of excellence has been in agricultural research where ACIAR has a strong record of achievement stretching back over several decades. Independent evaluations show that ACIAR has performed impressively, but its overall funding remains modest. Increased funding for agricultural research seems warranted given high prices and serious concerns around food security."

—Independent review of aid effectiveness, April 2011.

"Australia's support for Timor Leste has played an important role in helping overcome the sense of fragility that followed independence and threatened the confidence of our people in our institutions. Today that fragility is being replaced by a cautious, but growing sense of optimism."

—East Timor's former President and Nobel Prize recipient, José Ramos-Horta, 2012.

"In particular ACIAR's emphasis on agricultural research to achieve sustainable development and natural resource management funds research that directly contributes to Australia's pursuit of better outcomes in areas such as water management, soil degradation, biodiversity and climate change responses. Similarly, ACIAR's projects dealing with food safety, animal and crop health and biosecurity concur with and contribute to Australia's need to maintain and enhance its agricultural and food health and safety status."

— The Centre for International Economics in its submission to the Productivity Commission Study on Public Support for Science and Innovation, 2006.

"Fortunately, the impact and influence that Australians have had on world agricultural development has been much greater than is implied by the size of Australia's aid budgets. When praising the 'magnificence' of Australia's contribution to international agricultural research and development, David Hopper, a former senior vice-president of the World Bank, pointed out that: 'This is partly explained by the fact that, for a developed country, Australia has a high proportion of sub-tropical agriculture. But equally important—indeed perhaps more important—is that Australia has produced, and continues to produce, men and women of talent and vision who have recognised the contribution international agricultural research can make toward human development and have not hesitated to immerse themselves in the process'. "

—Derek Tribe, author of *Doing Well by Doing Good*, published in 1991.

"ACIAR performs an important function independently in the aid program in improving the well-being of people in developing countries and Australia through collaborative research partnerships aimed at the development of sustainable agricultural systems and the design of appropriate natural resource management strategies. ACIAR's projects mobilise Australian research expertise, thereby contributing to building research capacity both in Australia and developing countries."

— Government response to the 1992 review of ACIAR's sunset clause by the Parliamentary Joint Committee on Foreign Affairs, Defence and Trade.

"Australia's working relationships with the CGIAR, particularly CIMMYT, ICRISAT, and ICARDA, is critical to the flow of knowledge and plant genetics into our own crop improvement programs. ACIAR's high standing within the global agricultural research community has been central to this , with the GRDC a long-standing supporter and partner in our combined efforts to not only improve the circumstances of Australian farmers, but farmers in poorer countries for whom crop productivity is fundamental to improving people's lives."

—John Harvey, managing director of the Grains Research and Development Corporation (GRDC), 2012.

"Over the past 30 years, ACIAR has played an outstanding leadership role in Australia' s engagement in international agricultural research, development, extension and education in developing countries in Asia, the Pacific region, the Middle East and Africa. This has imparted knowledge and skills and delivered sustainable technologies for local conditions which have contributed to global food security. The most uplifting aspect of the capacity building is that it empowers people and provides the opportunities that short term welfare can never match. The value of international genetic resources of grain crops to Australian agriculture has been enormous. The role of ACIAR in collaboration with CGIAR Centres and national programs to help fund new collections, expeditions and evaluation of genetic resources including collaborations across national and international borders has been invaluable and commendable."

—Hackett Professor Kadambot Siddique, AM FTSE FAIA, Chair in Agriculture and Director, the University of Western Australia Institute of Agriculture.

NEW PUBLICATIONS

For details on ACIAR's scientific publications series and corporate publications please visit: http://aciar.gov.au/publication/latest

FEATURED PUBLICATION

MELALEUCAS: THEIR BOTANY, ESSENTIAL OILS AND USES is a visually stunning A4 book with colour photos of nearly 300 species of the genus. Detailed analyses of each species' oil profile are provided in a companion website.

Species of Melaleuca are used for producing essential oils, land rehabilitation, pole production, and horticulture in Australia and the Asia-Pacific. To date, there has been a lack of published comprehensive information about the genus.

The book covers the botanical characteristics, distribution maps, commercial and ornamental uses of Melaleuca, along with information on propagation, production, pests and diseases, and conservation.

The guide was written by three Australian scientists with extensive experience with Melaleuca. It builds on ACIAR's research program on Melaleuca essential oils industries in Australia, Indonesia and Papua New Guinea.

The essential oils program of the Rural Industries Research and Development Corporation funded a major field collection in Western Australia to fill gaps in species coverage for the guide. MELALEUCAS: THEIR BOTANY, ESSENTIAL OILS AND USES is available as a free download or in hard copy ($85, incl GST) from ACIAR's website (www.aciar.gov.au)

PHOTO:123RF.COM

PHD FROM EAST TIMOR TO ADDRESS HUNGER

ACIAR ACTION East Timor's agricultural sector—including its technical and educational capacity—was devastated leading up to independence in 1999. ACIAR's Seeds of Life program has provided assistance, rebuilding that capacity through farm-centric research that seeks to help the 40% of households that were experiencing hunger for up to four months a year. ACIAR is also helping to train a new generation of agricultural scientists to carry on the work—people such as Dr Marcal Gusmao, who received an ACIAR John Allwright Fellowship to undertake a PhD at the University of Western Australia (UWA). He worked on the development of a legume crop that is tolerant to both drought and waterlogging and became UWA's first PhD recipient from East Timor. His doctorate in agricultural science enables Dr Gusmao to pass on methods of improving crop yields to his students at the National University of Timor-Leste, where he is also working for a United Nations development program on climate change. Dr Gusmao's PhD research involved assessing grass pea, which, unlike other legumes, yields well under stress.

PHOTO: UNIVERSITY OF WESTERN AUSTRALIA

(From left) Emeritus Professor Alan Robson, former UWA Vice-Chancellor, crop researcher Dr Marcal Gusmao, principal supervisor Erik Veneklaas and Dean of the Graduate Research School, Winthrop Professor Alan Dench.

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ACIAR RESEARCHERS AND THE NATION'S HONOUR ROLL

ACIAR ACTION The value of 'scientific diplomacy'—in which agricultural research for development helps build bridges and cooperation between nations—has received increasing recognition within Australia. The Order of Australia (OA) is the pre-eminent award that recognises the achievements and service of Australians. Long-time ACIAR collaborator Rob Williams received a Medal of the Order of Australia in 2012 for services to overseas humanitarian aid projects, particularly his dedication to rebuilding East Timor's agricultural sector as part of ACIAR's Seeds of Life program. This program introduced high-yielding seed varieties of five staple crops—maize, rice, sweetpotato, peanuts and cassava—to replace those destroyed or lost during the struggle for independence. About 3,000 East Timorese farms took part in the initial participatory research, providing feedback on the varieties' yields, storage abilities, taste and returns at the market. By 2009, about 100 tonnes of seed was distributed through the program to 20,000 farming families. Currently, the program is in its third phase and targeting varieties to more than 100,000 farming families. Rob Williams follows in the footsteps of Dr Harry Nesbitt, who was also involved in Seeds of Life. Dr Nesbitt was recognised in 2003 for extraordinary contributions to avert famine in Cambodia following the fall of the Khmer Rouge regime and as part of the Cambodia International Rice Research Institute–Australia Project. In 2011, Dr Robyn Alders was also honoured for distinguished service to the Australian poultry industry and to the maintenance of food security in developing countries, especially Africa, through disease-control programs.

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ACIAR'S VISION

ACIAR looks to a world where poverty has been reduced and the livelihoods of many improved through more productive and sustainable agriculture emerging from collaborative international research.

The Australian Centre for International Agricultural Research (ACIAR) operates as part of Australia's international development cooperation program, with a mission to achieve more productive and sustainable agricultural systems for the benefit of developing countries and Australia. ACIAR commissions collaborative research between Australian and developing-country researchers in areas where Australia has special research competence. It also administers Australia's contribution to the International Agricultural Research Centres.

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