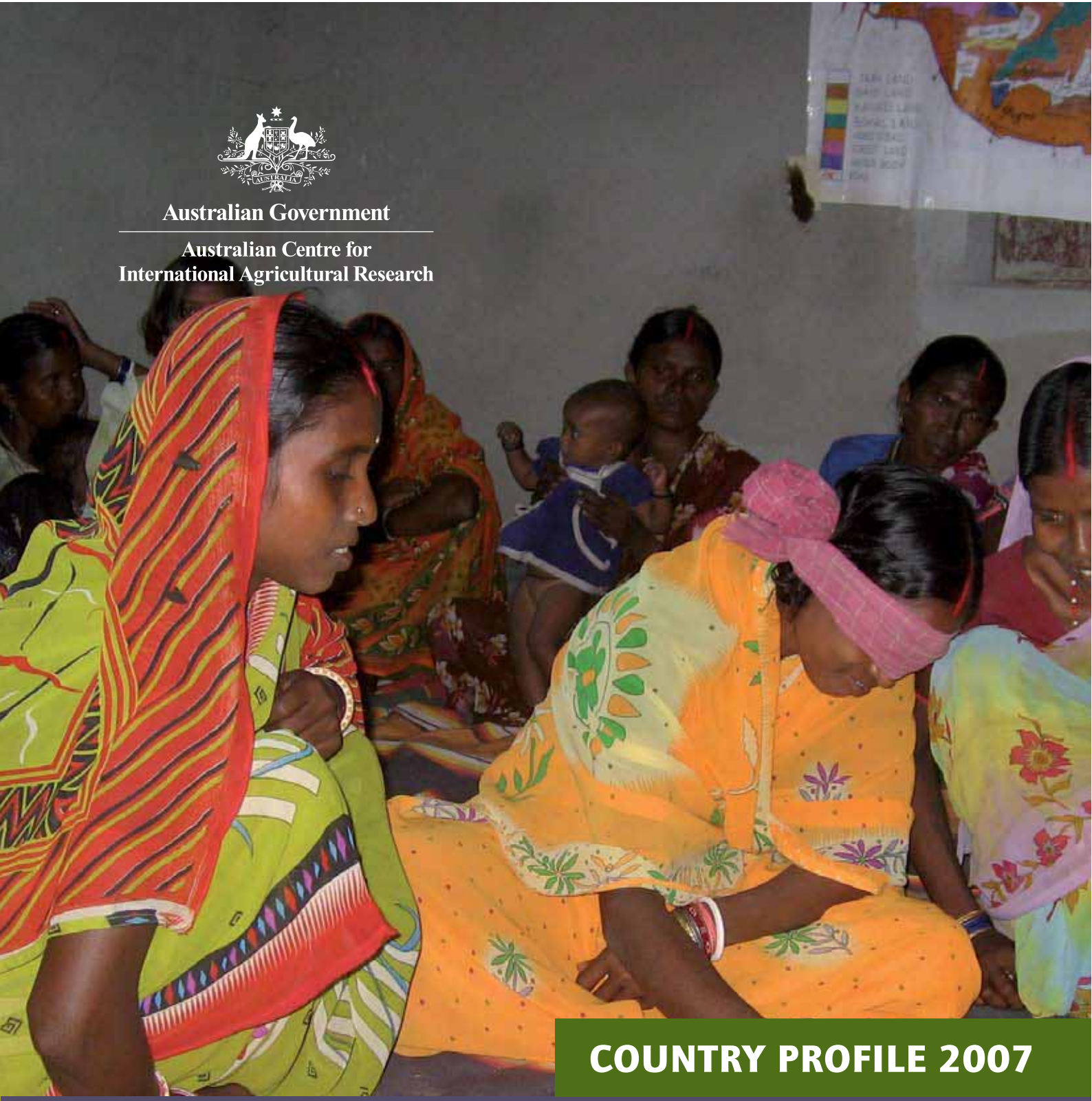
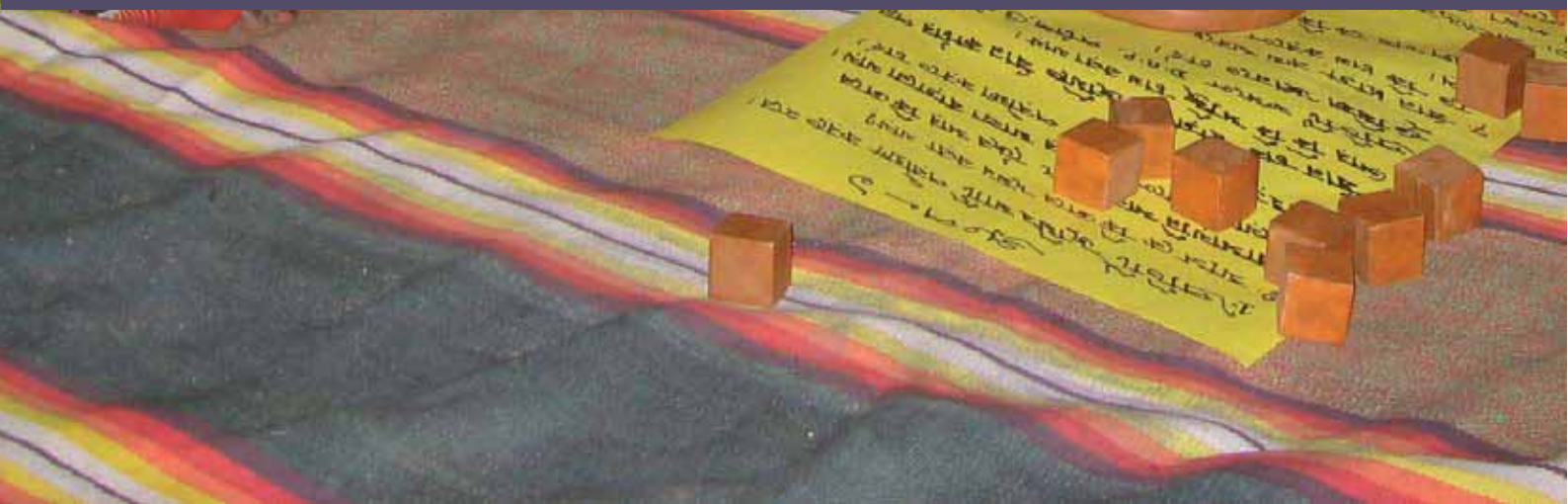


Australian Government

Australian Centre for
International Agricultural Research

COUNTRY PROFILE 2007

SOUTH ASIA



Australian Government

Australian Centre for
International Agricultural Research

COUNTRY PROFILE 2007

SOUTH ASIA

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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Contents

1 Preface

The ACIAR Country Profiles are designed to give a snapshot of the collaborative research being carried out between Australia and our various partner countries. This publication contains short summaries of bilateral and multilateral projects with South Asia that were active from 1 July 2006 to 30 June 2007. At that time there were 27 active bilateral projects, and seven active multilateral projects, the latter being led by international agricultural research centres. There were another 17 projects under development, many of which are expected to start in 2007–08 financial year.

This publication also sets out the key outputs and outcomes from 14 bilateral projects and two multilateral projects that have been completed between 1 July 2006 and 30 June 2007.

In addition to these project summaries, the publication includes an extract from ACIAR's 2006–07 Annual Report covering South Asia, our near-term program as outlined in the 2007–08 Annual Operational Plan, and a summary of ACIAR's training program.

ACIAR updates this profile each year and distributes it to key stakeholders in South Asia and Australia.

We hope you find the publication useful as a record of the progress and achievements between South Asia and Australia. For information on ACIAR's overall program, we invite you to visit our website at www.aciar.gov.au.

Peter Core
Chief Executive Officer
November 2007

Kuhu Chatterjee
ACIAR Country Manager, South Asia

2 Overview

2.1 ACIAR

The Australian Centre for International Agricultural Research (ACIAR) is an Australian Government Statutory Authority that operates within the portfolio of Foreign Affairs and Trade. It was established in June 1982 under the ACIAR Act to assist and encourage Australia's agricultural scientists to use their skills for the benefit of developing countries, and at the same time work to resolve Australia's own agricultural problems.

ACIAR's aims to enhance rural household incomes and broader economic growth by investing in international research partnerships that encourage agricultural development, sustainable use of natural resources and capacity-building of benefit to partner countries and Australia.

Research funded by ACIAR is mutually beneficial to Australian and developing country rural industries by harnessing Australia's outstanding strengths in agricultural research to develop partnerships with developing country research institutions.

ACIAR is based in Canberra, with offices in China, India, Indonesia, Papua New Guinea, the Philippines, Thailand and Vietnam.

Australia is in a particularly strong position to provide such assistance because it has a broad range of climates – cool and warm temperate, subtropical and tropical – that are typical of the developing world. Australia's scientists work within a very strong network of institutions, such as the CSIRO, Federal and state government organisations and universities.

The Australian Centre for International Agricultural Research (ACIAR) carries out research in the Asia-Pacific region, and currently has projects in the following regions:

- South-East Asia (Vietnam, Cambodia, Laos, Thailand, Indonesia, Philippines: >45% bilateral expenditure)
- Papua New Guinea and the Pacific islands (>20% of bilateral expenditure).
- North Asia (China: <15% of bilateral expenditure)
- South Asia (India, Pakistan, Bangladesh, Bhutan, Afghanistan, Iraq: <15% of bilateral expenditure)

ACIAR is also responsible for Australia's relationship with the International Agricultural Research Centres—the Consultative Group on International Agricultural Research (CGIAR) centres. ACIAR's annual outlay to the CGIAR centres is around $11 million.

These funds are used to facilitate CG engagement in the Asia-Pacific and to commission projects that are consistent with ACIAR's country program strategies.

2.2 Country Portfolio

India

ACIAR has supported a program of collaborative agricultural research with India since 1983. Most of the program consists of bilateral projects, in which an Australian research organisation is commissioned to undertake a specified research activity in collaboration with a partner organisation in India. India is also targeted in ACIARs multilateral program delivered in conjunction with the international agricultural research centres.

ACIAR's program with India as at 30 June 2007.

Bilateral Program

Active projects	20 with a value over their lifetime of approximately $11,113,322
Projects under development	13
Share of South Asia program	$1,770,516 which represents 40.5% of the total 2006-2007 South Asia program.
Completed projects	48

Multilateral Program

Active projects	3 with a value over their lifetime of approximately $2,907,398
Projects under development	2
Completed projects	18

Pakistan

ACIAR has supported a program of collaborative agricultural research with Pakistan since 1984. Most of the program consists of bilateral projects, in which an Australian research organisation is commissioned to undertake a specified research activity in collaboration with a partner organisation in Pakistan. Pakistan is also targeted in ACIARs multilateral program delivered in conjunction with the international agricultural research centres.

ACIAR's program with Pakistan as at 30 June 2007.

Bilateral Program

Active projects	9 with a value over their lifetime of approximately $6,786,017
Projects under development	3
Share of South Asia program	$1,658,786 which represents 38.0% of the total 2006-2007 South Asia program.
Completed projects	18

Multilateral Program

Active projects	0 with a value over their lifetime of approximately $0
Projects under development	0
Completed projects	7

Bangladesh

ACIAR has supported a program of collaborative agricultural research with Bangladesh since 1994. Most of the program consists of bilateral projects, in which an Australian research organisation is commissioned to undertake a specified research activity in collaboration with a partner organisation in Bangladesh.

The Multilateral program is delivered in conjunction with international agricultural research centres, in particular the International Maize and Wheat Improvement Center (CIMMYT) headquartered in Mexico with a regional office in Dhaka.

ACIAR's program with Bangladesh as at 30 June 2007.

Bilateral Program

Active projects	3 with a value over their lifetime of approximately $2,646,596
Projects under development	0
Share of South Asia program	$413,045 which represents 9.5% of the total 2006-2007 South Asia program.
Completed projects	9

Multilateral Program

Active projects	1 with a value over their lifetime of approximately $398,915
Projects under development	1
Completed projects	4

Other South Asian and Middle East countries: Bhutan

ACIAR has supported a program of collaborative agricultural research with Bhutan since 1998. Most of the program consists of bilateral projects, in which an Australian research organisation is commissioned to undertake a specified research activity in collaboration with a partner organisation in Bhutan.

ACIAR's program with Bhutan as at 30 June 2007.

Bilateral Program

Active projects	1 with a value over their lifetime of approximately $765,647
Projects under development	0
Share of South Asia program	$121,340 which represents 2.8% of the total 2006-2007 South Asia program.
Completed projects	3

Multilateral Program

Active projects	0 with a value over their lifetime of approximately $0
Projects under development	0
Completed projects	1

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3.3 Policy Advisory Council member

The ACIAR Policy Advisory Council is established under the Australian Centre for International Agricultural Research Act 1982. Members are appointed by the Minister for Foreign Affairs, and represent ACIAR's key stakeholders or the implementing agencies for ACIAR's program in partner countries and Australia. Council members are drawn from government departments, research providers and industry, and are therefore well placed to advise on their respective countries' development and agricultural priorities and research needs.

The current member from India is Dr Mangala Rai, Director General, Indian Council of Agricultural Research (ICAR) and Secretary, Department of Agricultural Research and Education (DARE). Dr Rai has been a member of the Council since March 2003.

4 Training

The ACIAR training program has a budget in 2007-08 of approximately $5.57 million. It comprises five elements:

- Fellowships for postgraduate students (John Allwright Fellowships)
- Postgraduate returnee follow-up awards (Returnee Small Project Awards Scheme)
- Leadership development opportunities for developing country scientists (John Dillon Memorial Fellowships)
- Non-award training (short courses and workshops)
- Support for the Crawford Fund, both through management of the Australian Government's contribution ($0.70 million) and sponsorship of attendees at Masterclasses and other selected training activities.

Much of ACIAR's training is carried out systematically within individual projects. In addition, specialised, discipline-specific training activities may also occur within ACIAR's individual research and development programs.

The ACIAR John Allwright Fellowship Scheme accounts for approximately $4.53 million (this figure includes $3 million from AusAID) of the training program budget in 2007-08. The objective of the Scheme is to increase the research and development capacity of ACIAR partner country institutions. It provides funding for promising overseas researchers associated with ACIAR projects to undertake postgraduate studies in tertiary institutions in Australia.

India John Allwright Fellowship Statistics

		PhD	MSc/Other
Active	Male	2	0
	Female	2	0
Concluded	Male	3	1
	Female	3	0

Pakistan John Allwright Fellowship Statistics

		PhD	MSc/Other
Active	Male	0	0
	Female	0	0
Concluded	Male	3	1
	Female	0	0

Bangladesh John Allwright Fellowship Statistics

		PhD	MSc/Other
Active	Male	0	0
	Female	0	0
Concluded	Male	0	0
	Female	1	0

Bhutan John Allwright Fellowship Statistics

		PhD	MSc/Other
Active	Male	0	1
	Female	0	0
Concluded	Male	0	0
	Female	0	0

PART 1: INDIA

5 Annual Report 2006-07

Active projects in 2006-07	29
AOP budgeted expenditure in 2006-07	$2,017,584
Actual expenditure in 2006-07	$1,770,516
Expenditure in 2005-06	$2,018,915
Expenditure in 2004-05	$2,601,365

Key performance indicators	Performance 2006-07
Significant involvement of farmers and farmer communities in planning and testing ACIAR project technologies in at least two projects.	Farmers near Ludhiana started testing the Happy Seeder technology in collaboration with the machinery manufacturer and Punjab Agricultural University. In West Bengal, the NGO PRADAN is working with two communities to increase farm productivity at a small watershed scale.
Policy workshops and papers in trade and water management reaching key government planners.	Water management workshops held successfully in India and Australia involving senior Indian National and State government decision makers.
Forward strategy for ACIAR involvement in the Indian livestock sector developed and communicated.	In a consultation with stakeholders it was decided to discontinue investment in the livestock sector in India. Livestock Strategy Paper approved by the ACIAR Board.
Significant adoption by tanneries of salinity-reducing techniques for processing hides.	Activities interrupted due to a change in leadership at the Central Leather Institute. Adoptions of new strategies to manage salt effluent, including those assessed in the research, are being adopted due to regulatory intervention.
Production constraints in soybean-wheat systems of Madhya Pradesh identified and appropriate research strategies implemented.	Key growth limiting nutrients and other constraints such as waterlogging have been identified, and NGO partner testing integrated nutrient management techniques and 'broad-based furrow' system with farmer groups.
Preliminary catchment water balances in the Krishna Basin quantified and used to inform water policy decision-making at national and state levels.	General water balances for the Krishna Basin have been compiled and communicated on a State scale to key stakeholders in Karnataka, Maharashtra and Andhra Pradesh.
Forty per cent of new projects designed to have significant farmer or policymaker impacts within five years of completion.	Only one new standard project was initiated in 2006/07 and this was rated as a medium time to impact project. A small research activity will achieve significant implementation of shrimp farming best management practices within five years.

5.1 Position

India, the world's largest democracy, faces huge problems in its rural sector even as the overall economy forges ahead. Indeed, the greatest numbers of poor and undernourished in any country (approximately 250 million) are found in India, particularly in rural areas.
At the same time India faces trade liberalisation and rapid diversification of diet towards high-value agriculture. Recent analyses by the International Food Policy Research Institute (IFPRI) however confirm that investment in agricultural R&D has powerful impacts on agricultural growth and poverty reduction.

Following changes in 2003, and recent discussions in India, it is expected that ACIAR collaboration with the Indian Council of Agricultural Research (ICAR) and the Council of Scientific and Industrial Research (CSIR) on future projects will involve joint funding and focus on high priority issues or strategic alliances of mutual interest.

Funding is also available from the Australian Government Department of Education, Science and Training Australia-India Strategic Research Fund to assist Australian researchers to increase their participation in leading edge scientific research with Indian scientists, to raise the profile of Australian research, and to support the development of strategic alliances between Australian researchers and Indian researchers and industry.

The Government of India is also encouraging donors to work with independent research organisations (IROs) and NGOs, and ACIAR has taken up this challenge. This will help the goal of increased emphasis on achieving practical farmer-level impacts, particularly in poorer regions of India. The strategy of working in the central and north-western parts of the country will be maintained, given its closer match to Australian agro-ecological zones.

India was one of the first countries to become involved in collaborative projects commissioned by ACIAR. An earlier project on wheat rust control by identifying the various rust races and by the identification and deployment of resistance genes has helped to keep India free of major rust epidemics, with obvious benefits for poor farmers and consumers alike. A molasses-based nutrient block with medication to supplement diets and control internal parasites of straw-fed dairy animals has been developed. For stored commodities, improved means of managing resistance to the fumigant phosphine and of detecting persistent pesticide residues have been developed. Recent research has assisted in the widespread adoption of minimal tillage approaches in wheat seeding in the rice–wheat farming systems, with significant benefits arising from water and fuel saving, timelier sowing, and easier weed management.

India has a large and well-developed national agricultural research system, centred around ICAR, which has collaborated strongly in ACIAR projects. Additional linkages with other groups such as state agricultural universities, CSIR, Independent Research Organisations and technical NGOs have facilitated technology development and the delivery of benefits. ACIAR engages mainly with researchers in the north-west and centre of India, with research projects presently under way to enable India to manage scarce water and nutrient resources more efficiently, improve yield and quality of cereals and oilseeds, and diversify production and raise farm incomes.

A number of IARCs are also active in India. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is headquartered in Hyderabad. It has strong programs on peanut, sorghum, millet and chickpea, crop–livestock systems (with the International Livestock Research Institute, ILRI) and on soil management in the semi-arid tropics. The International Maize and Wheat Improvement Center (CIMMYT) and the International Rice Research Institute (IRRI) have significant regional activities in India, many connected with the rice–wheat eco-regional initiative. The International Water Management Institute (IWMI) has a joint program on policy issues with an Indian Research Institute and other biophysical programs in India. ACIAR supports projects with these IARCs.

5.2 Relationship to the AusAID South Asia strategy

The AusAID Framework for assistance in South Asia over 2003-07 ‘seeks to maximise the effectiveness of programs reducing vulnerability and increasing the productivity of the poor’ with an emphasis in the areas of ‘health and sanitation, education and natural resource management’. It recognises that countries ‘are at different stages of development, each with their own development priorities’—for example, in Bangladesh there is a shift in focus from food aid assistance to food security.

The ACIAR program, while emphasising the agriculture sector, also has a strong emphasis on reducing vulnerability and increasing productivity of the poor. In India, there is an increased focus on boosting sustainable production in more marginal lands of the country, and in technical and policy interventions to support on-going access to water. Policy reform is supported through collaboration on trade and natural resource management policy.

5.3 Achievements

India needs to **improve the overall productivity of ruminants**, especially milk-producing cattle and buffalo. It can do so by more effective and efficient use of feedstuffs, including cereal straws and other waste by-products. Scientists working in a project to improve the efficiency of feed utilisation have developed technology for preparing feed supplements that comprise by-pass proteins (which are not digested by bacteria in the rumen, but by enzymes further down the gut) and fats produced from by-products such as oilseed meals, groundnut and palm oil cakes/residues. In trials undertaken in cows/buffaloes in the states of Gujarat, Haryana, Orissa, and Kerala feeding 1 kg per day of by-pass protein supplements, compared with one kg of untreated meal, increased milk yield, fat and protein content and lifted the incomes village dairy farmers. The tangible economic benefits of these feeding trials has led to the design, construction and operation of a commercial plant capable of producing up to 50 tonnes per day of by-pass protein feed supplement.

ACIAR has contributed to the development of no-till systems for wheat in India, and now preliminary research suggests **no-till rice** can also be grown. This would substantially boost the benefits of no-till wheat, which are often subsumed by tillage and puddling in rice cultivation. A project is aiming to improve the productivity of direct-seeded rice through the application of improved weed and crop management technologies, and thus minimise the yield gap between wheat and rice. Trials are under way at several sites. Studies on sowing time of direct-seeded rice undertaken at the Experimental Farm of the Rajendra Agricultural University in Bihar revealed that long- and short-season varieties perform very differently in response to delayed planting time. In the long-season variety, grain yield declined significantly with delayed seeding, but short-season varieties performed better. Therefore, selection of appropriate varieties for direct-seeded rice appears to be pivotal to the success of the project.

In West Bengal, drying maize and rice is inefficient and unreliable, and more attention is needed to remove moisture and maintain quality during storage and transport. In an attempt to modernise the region's grain industries a project has been commissioned to **design and introduce drying systems** that reduce risk of loss of grain quality after harvest. The project team has constructed a two-stage drying system that comprises a fluid bed first stage for rapid removal of moisture down to around 17%, followed by a slower in-bin system to achieve safe storage levels of moisture content. Laboratory-scale units for both drying processes were constructed and tested for performance. Now a commercial prototype two-stage dryer, based on the laboratory scale units, has been constructed by a local fabricator and installed in the Burdwan Government Seed Farm as a demonstration unit for drying paddy rice seed.

The East Indian plateau, covering three Indian states, receives high rainfall (in excess of 1200 mm a year) but 80 per cent of this falls in the monsoon months between June and September. Despite the high rainfall, water shortages are a problem, with high runoff and little, if any, water harvesting practiced. Cropping intensity is low, with one crop only year, timed to maximise available water. A project is **introducing watershed management**, including water harvesting, and testing new cropping and agronomic practices opportunities to improve livelihoods in this poor region of India. In the first step to develop a watershed development plan, PRADAN (an NGO) is undertaking socioeconomic 'mapping' to ascertain the resources available and list the constraints to development. PRADAN has also produced a 'resource map' of the Pogro watershed. A conceptual model for hydrology of small watersheds has been developed, and this could form the basis for modelling that will develop criteria for either assessing the suitability of small watersheds for development or for the planning, design and installation of water-harvesting measures.

Culturing shrimp is a potentially lucrative industry in both Asia and Australia, but many Asian farmers have seen profits eroded by disease outbreaks. The pathogen of greatest concern is **white spot syndrome virus (WSSV)**. A clearer understanding is needed of WSSV transmission sources and routes, such as infected seed stock. Polymerase chain reaction (PCR) methods for screening are often limited, particularly on-farm, and a project is making PCR screening more effective. A major experimental component is a longitudinal study of shrimp ponds in the West Godavari District of Andhra Pradesh, India. The aim is to obtain information on the quality of PCR screening results available to farmers and to use molecular epidemiological analysis to trace the sources of disease outbreaks in ponds. Farmers participating in the study are members of 'aquaclubs' formed as part of an ongoing extension program of best management practices. Their farms were stocked with PCR-screened post-larvae (PLs) obtained from local hatcheries. When shrimp were PCR tested the results indicated there was a very high prevalence of WSSV infection in the study ponds, with a high proportion of moderate–severe infections. A small number of nursery ponds were pinpointed as the source of seed for a high proportion of disease outbreaks during grow-out, and they are highly likely the weak link in current disease-management practice.

Agricultural knowledge, science and technology (AKST) have played key roles in reducing poverty. When they produce outcomes such as the Green Revolution, the benefits can be widespread. But would similar outcomes, if produced today, result in similar benefits? And what would be the pathway for delivering them to the world’s poor? An ACIAR project involving The World Bank and IFPRI is attempting to answer these and related questions, in order to determine appropriate pathways for development and for disseminating information to promote agricultural advances. The project goal is to provide policy-makers with options of alternative policies and investments for AKST. Using an expanded model proven in past research, a series of scenarios of future opportunities and alternative pathways for development is being described, with particular reference to India and China. Each scenario, presented with associated storylines, is being analysed prior to posting the results via the Internet for policy- and decision-makers.

6 Annual Operational Plan 2007-08

GNI per capita ($US)	720
Population	1,087.1 m
Population 2015/2050	1,260.4/1,592.7 m
Active bilateral projects	16
Active multilateral projects	4

Bilateral actual 2005–06*	$ 2.02 m
Bilateral estimate 2006–07**	$ 2.02 m
Bilateral budget 2007–08**	$ 2.20 m
Bilateral + multilateral budget 2007–08	$ 2.89 m

**Includes co-funding of projects ($0.09 m in 2006–07 and $0.09 m in 2007–08) by the Grains R&D Corporation

6.1 Key performance indicators (2007–08)

- An integrated cluster of linked projects designed and implemented around sustainable wheat farming systems in Northwest India
- A new collaborative program on marker-assisted breeding in wheat developed
- Improved soybean-wheat production systems being tested by farmers and propagated by NGOs in Madhya Pradesh
- Economic trade-offs of water allocation scenarios in the Krishna Basin quantified and communicated to water policy decision-making at national and state levels.
- Demonstrated influence of policy research outcomes on trade and water policy decision making processes
- 40% of new projects designed to have significant farmer or policymaker impacts within five years of completion

6.2 Medium-term strategy

The emphasis of ACIAR's India program is on maintaining sustainable wheat-based cropping in the more favoured areas of north-western India, achieved through application of better genotypes, better management technologies, and increased linkage of farmers to markets. In the less favoured areas of India's rain-fed Central Plateau, the emphasis is on broad-scale land and water resource management work, applying technical, economic and policy research approaches to increase water productivity. Both themes will be complemented by more general policy analysis work at the national level.

During 2007–08 there will be an increased focus on clustering projects around the two main themes. Project design principles include the involvement of farmers and NGOs, as well as engagement with policy makers with a view to achieving quicker impact. At the same time crop breeding projects will be using new molecular technologies that can hasten the release of better varieties, but these have a longer lead-up to farmer impact. Where relevant, ACIAR will link the projects to the CGIAR-coordinated regional Rice–Wheat Consortium for broader impact.

6.3 ICAR-ACIAR Program on Marker Assisted Breeding in Wheat

In discussions with the Indian Council for Agricultural Research, ACIAR has agreed to further focus the current emphasis on sustainable wheat cropping into a subprogram based around the application of marker assisted selection as a tool to achieve greater efficiencies in wheat breeding. In late 2007, a joint Indo-Australian workshop on marker assisted selection will identify the likely breeding objectives (biotic and abiotic stresses; quality traits) to be targeted, providing the basis from which a focussed 5 year program will be formulated and implemented in the course of 2008.

6.4 Position

India, the world's largest democracy, faces huge problems in its rural sector even as the overall economy forges ahead. Indeed, the greatest number of poor and undernourished people in any country (approximately 300 million) is found in India and most of these live in rural areas.

At the same time India faces trade liberalisation and rapid diversification of diet towards high-value agriculture. Recent analyses by the International Food Policy Research Institute support the long-held assertion that investment in agricultural R&D has powerful impacts on agricultural growth and poverty reduction.

Following changes in 2003, and recent discussions in India, it is expected that ACIAR collaboration with the Indian Council of Agricultural Research (ICAR) and the Council of Scientific and Industrial Research (CSIR) on future projects will involve joint funding and focus on high-priority issues or strategic alliances of mutual interest.

The government of India is also encouraging donors to work with independent research organisations and NGOs, and ACIAR has taken up this challenge. This will help the goal of increased emphasis on achieving practical farmer-level impacts, particularly in poorer regions of India.

India was one of the first countries to become involved in collaborative projects commissioned by ACIAR. An earlier project to control wheat rust by identifying the various rust races and by the identification and deployment of resistance genes has helped to keep India free of major rust epidemics, with obvious benefits for poor farmers and consumers alike.

A molasses-based nutrient block with medication to supplement diets and control internal parasites of straw-fed dairy animals has been developed. For stored commodities, improved means of managing resistance to the fumigant phosphine and of detecting persistent pesticide residues have been developed. Recent research has boosted the widespread adoption of minimal tillage for seeding wheat in the rice–wheat farming systems. Significant benefits have come from water and fuel saving, timelier sowing, and easier weed management.

India has a large and well-developed national agricultural research system, centred around ICAR, which has collaborated strongly in ACIAR projects. Additional linkages with other groups, such as state agricultural universities, CSIR, Independent Research Organisations and technical NGOs have facilitated technology development and the delivery of benefits.

Several significant programs have been recently initiated by ICAR, including the World Bank – funded National Agriculture Innovation Programme and the US–India Agriculture Knowledge Initiative, both of which share many of the same research priorities with the ACIAR program in India.

Against this backdrop, ACIAR will emphasise maximising technical collaboration in areas of Australian comparative advantage and in areas where both India and Australia have strong common interests and potential for field-level and trade impacts in both countries.

ACIAR will engage mainly with researchers in the north-west (Punjab, Haryana, with outreach to Rajasthan, Madhya Pradesh and Uttar Pradesh) and the Indian Central Plateau (Andhra Pradesh, with outreach to Karnataka, Maharashtra and West Bengal), with research projects presently under way to enable India to manage scarce water and nutrient resources more efficiently, improve yield and quality of cereals and oilseeds, diversify production and raise farm incomes.

Funding is also available from the Australia–India Strategic Research Fund (administered by the Federal Department of Education, Science and Training) to assist Australian researchers to increase their participation in leading-edge scientific research with Indian scientists, to raise the profile of Australian research, and to support the development of strategic alliances between Australian researchers and Indian researchers and industry.

The final implementation details of this three-year $20m program, have now been put in place with the government of India (Departments of Science and Technology, and Biotechnology). The initial priority areas are agricultural research, astronomy and astrophysics, environment sciences (including water), micro-electronics devices and materials, nanotechnology, renewable energy, and marine sciences. Application details can be accessed at https://sciencegrants.dest.gov.au/aisrf/Pages/STFund.aspx.

The Australian Department of Agriculture, Forestry and Fisheries has an increasing interest in India and its strategy has a strong trade focus, reflecting the increasing importance of India in the World Trade Organisation and as a future market for Australian agricultural commodities. Key areas of interest and interface with ACIAR comprise communication of Indian agriculture to Australian stakeholders and an understanding of the evolution of Indian policy frameworks.

A number of IARCs are also active in India. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is headquartered in Hyderabad. It has strong programs on peanut, sorghum, millet and chickpea, crop–livestock systems (with the International Livestock Research Institute, ILRI) and soil management in the semi-arid tropics. The International Maize and Wheat Improvement Centre (CIMMYT) and the International Rice Research Institute (IRRI) have significant regional activities in India, many connected with the rice–wheat eco-regional initiative. The International Water Management Institute (IWMI) has a joint program on policy issues with an Indian research institute and other biophysical programs in India. ACIAR supports projects with these IARCs.

6.5 Relationship to the AusAID South Asia strategy

The AusAID framework for assistance in South Asia over 2003–07 ‘seeks to maximise the effectiveness of programs reducing vulnerability and increasing the productivity of the poor’ with an emphasis on the areas of ‘health and sanitation, education and natural resource management’.

It recognises that countries ‘are at different stages of development, each with their own development priorities’. In India, AusAID is now solely focusing on HIV Aids and in north-eastern India is operating almost exclusively in multilateral mode (through UN agencies and NGOs).

6.6 Indicative priorities

ACIAR has a formal program of consultations with India to establish priorities in research collaboration. The most recent review of priorities was held over the July 2006 – May 2007 period from which several focal areas emerged:

Subprogram 1. Sustainability of wheat-based cropping systems in NW India

- Maintaining productivity and increasing profitability of wheat-based cropping systems
- Dealing with water scarcity in wheat-based irrigated systems
- Application of biotechnology to crop improvement

Subprogram 2. Water management for enhanced livelihoods in rain-fed areas of the Central Plateau, with emphasis on Andhra Pradesh

- Sustainable water harvesting and watershed development
- Informing water resource management and policy making to optimise water productivity
- Improving the water productivity of rain-fed cropping and livestock systems

Subprogram 3. Policy options for trade and market reform to underpin agribusiness development

- Adjusting to the challenges and opportunities of international trade
- Enabling private sector investment in agribusiness and marketing
- Safeguarding smallholder livelihoods in the transition from regulated to market economy.

7 Projects (summary and progress reports)

7.1 Subprogram 1: Sustainability of wheat-based cropping systems in north-west India

Projects:

Active

CIM/1999/072	Oilseed Brassica improvement in China, India and Australia
CIM/2003/067	Ensuring productivity and food security through sustainable control of yellow rust of wheat in Asia
LWR/2002/032	Integrated manure nutrient management in soybean/wheat cropping systems on vertisols in Madhya Pradesh and Queensland
LWR/2004/033	Zero-tillage rice establishment and crop-weed dynamics in rice and wheat cropping systems in India and Australia
LWR/2006/124	Fine-tuning the Happy Seeder technology for adoption in northwest India

Concluded

CIM/1996/025	Physiological and genetic approaches for the development of waterlogging tolerance in wheat on sodic/alkaline and neutral soils in India and Australia
CIM/2001/026	Drying systems to improve grain quality in north-east India
FIS/2005/176	Masterclass – Aquaculture Nutrition Master Class
HORT/2002/030	Improving sub tropical citrus production in Sikkim and Australia
LWR/2000/089	Permanent beds for irrigated rice-wheat and alternative cropping systems in north-west India and south-east Australia
LWR/2005/059	Modelling water and solute processes and scenarios for optimisation of permanent raised bed systems in China, India, Pakistan and Indonesia

Pipeline

ADP/2007/062	Facilitating agricultural sector reforms in India: An assessment of regulatory and competition policy requirements
CIM/2005/20	Molecular marker technologies for faster wheat breeding in India
CIM/2006/071	Root system traits to improve grain yield and drought resistance of wheat in Australia and India
CIM/2006/094	Enhancing farm profitability in northwest India and South Australia by improving grain quality of wheat
CIM/2006/177	Wheat improvement for waterlogging, salinity and microelement toxicities in acidic and sodic soils in India and Australia
CIM/2007/064	Linking India and Australia to a global strategy for the Ug99 stem rust pathotype

CIM/1999/072: Oilseed Brassica improvement in China, India and Australia

Bilateral

Overseas Collaborating Countries	China, India
Commissioned Organisation	University of Melbourne, Institute of Land and Food Resources, Australia
Project Leader	Dr Phil Salisbury Phone: 03 8344 7315, 9884 8068 Fax: 03 8344 4665, 9884 8068 Email: p.salisbury@unimelb.edu.au
Collaborating Institutions	Department of Primary Industries, Victoria, Australia South Australian Research and Development Institute, Australia National Research Centre on Rapeseed-Mustard, India NSW Department of Primary Industries, Australia Oil Crops Research Institute, China University of Western Australia, Australia Punjab Agricultural University, India Tata Energy Research Institute, India Indian Council of Agricultural Research, India Huazhong Agricultural University, China Haryana Agricultural University, India Department of Agriculture, Western Australia, Australia Institute of Industrial Crops, China
Project Budget	$2,607,087
Project Duration	01/01/2004 to 31/12/2008
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Oilseed brassicas are an extremely important crop in China and India. More than 6 million hectares are planted to *B napus* (rapeseed) in China and *B. juncea* (Indian mustard) in India. Achieving canola quality oils (low in erucic acid and glucosinolates) is an aim for both countries. *B napus* varieties grown in Australia, Europe and Canada all achieve canola quality. Of the *B napus* types grown, those planted in Australia are best suited to Chinese and Indian growing conditions. Germplasm with improved traits for both *B napus* and *B juncea* will be tested to improve canola quality oilseed production in China, India and Australia.

Brassica production in all three countries is limited by a number of key diseases and environmental stresses. *Sclerotinia* and white rust resistant traits are needed to reduce the losses these diseases cause. Agronomic traits such as drought tolerance and quality will also boost yields and oil quality. Molecular genetic and quality analysis can be used to determine key traits including quality, disease resistance and drought tolerance.

This project is:

- identifying and developing effective screening/evaluation protocols for each key trait
- identifying appropriate variability for key traits through use of screening protocols
- enhancing germplasm in all countries for key traits through selection and breeding
- identifying heritability of key traits, genetic distance and heterotic pools (agronomic analysis, molecular analysis) by undertaking genetic variability/distance studies on germplasm from all countries
- developing and providing appropriate information on improved germplasm and disease epidemiology for incorporation into existing technology transfer protocols.

Project Progress

Year 3 (01/01/2006–31/12/2006)

Advances were made in 2006 in the development of screening protocols for sclerotinia and white rust resistance. Severity of *Sclerotinia* infection was found to be related to stem diameter and stem lesion length 3 weeks after inoculation and was significantly and positively correlated with the percentage of plant death at maturity, which indicated the value of the stem inoculation method for the effective identification of *Sclerotinia* resistance under field conditions (UWA-B).Assessment of white rust screening protocols demonstrated that controlled environmental conditions are suitable for rapid identification of resistant genotypes, and that genotypes with high levels of resistance can be reliably identified at the cotyledonary, seedling, or flowering stages (UWA-B).Pathotyping experiments of the white rust pathogen have identified only Race 2 pathotype 2A isolates in Australia to date (UM). Further surveying is under way to determine if the virulent pathotype (2V) is present in Australia.

During 2006 considerable progress was made in the identification of variability for key agronomic, quality and disease resistance characters in the Indian, Chinese and Australian *B napus* and *B. juncea* germplasm in each country. In addition, breeding programs to enhance the germplasm in all countries for shatter resistance, disease resistance, agronomy and quality and drought tolerance characters progressed. Crossing programs, which were initiated in 2005, have advanced significantly, and the first generation of populations developed from the crosses have been sown and are currently being screened.

Some key characters that were identified in the germplasm screening that will be beneficial to the breeding of improved lines for each country included: white rust resistance in Australian and Chinese *B. juncea* lines; low erucic acid and low glucosinolate levels in Chinese and Australian *B. napus* and *B. juncea* lines; drought tolerance in Australian *B. juncea* lines; variation for *Sclerotinia* tolerance among all *B. napus* lines (varied among locations); potential blackleg resistance in Chinese and Indian *B. juncea* germplasm in Australia.

Cluster analysis of Australian and Indian *B. napus* and *B. juncea* varieties by HAU and PAU showed no association between geographical distance and divergence based on morpho-physiological traits as genotypes from different locations fall in the same group and vice versa, which may be due to continuous exchange of germplasm.

Extensive work was undertaken in China (HZAU, IOCR, XAAS), India (HAU, PAU) and Australia (UWA-C) during 2006 to identify genetic distance, heterotic pools and heritability of key traits in the germplasm. Dendrograms showing the relationships among the 48 *B. napus* lines have been prepared at UWA-C and HZAU. Clustering in the HZAU dendrogram indicated that the Chinese *B napus* lines were relatively more genetically diverse. Clustering in the UWA-C diagram showed the clear distinction of Indian *B. napus* to accessions from other countries, and a higher proportion of ‘private alleles’ in Indian and some Chinese accessions. Genetic distance analysis of *B. juncea* is also under way at UWA-C.

Crosses have been made for hybrid vigour studies and at most institutes the F1 generations have been sown or will be sown soon. At UWA-C, selections were made for F1 hybrid evaluation based on the most homozygous selfed plants from each accession. Results from India (PAU), indicate that hybrids involving Australian *B. napus* germplasm and Indian non canola types were most productive. In China, (HZAU), examination of *B. napus* hybrids at the vegetative stage found positive mid-parent heterosis. Analysis of hybrid vigour in *B. juncea* was undertaken in China (XAAS) with diallel crosses using five Australian and five Chinese lines. The productivity of most of the F1s was higher than their parents and although the maturity of the varieties from both Australia and China was similar, the maturity of F1s was later than their parents.

Preliminary data have been generated in China to study the relationship between hybrid performance of *B. napus* and genetic distance. Results from IOCR indicate the performance of hybrids for yield traits was not consistent with genetic distances, although the genetic distances did show correlation with hybrid performance to a certain degree.

At HZAU, neither a positive nor negative relationship was observed between molecular genetic distance and mid-parent heterosis for seedling traits of the F1 hybrids. Further analysis is under way to determine whether or not correlations exist between F1 seedling characters and F1 yield and yield-related characters, and between F1 yield and yield-related characters and their parents' molecular genetic distance.

During 2006 significant progress was also made towards the objective of increasing the scientific skills of scientists collaborating in the project through scientific exchanges. Mr Wan Zhengjie (PhD student), Huazhong Agricultural University, Wuhan, began 5 months of molecular biology training at UWA in Assoc Prof Wallace Cowling's laboratory on 30 October 2006.
He will work on two projects at UWA: (i) identification of a gene for male sterility in *B. juncea*, and (ii) genetic distance studies on *B. juncea* in the ACIAR project collection. Mr Mei Desheng, Oil Crops Research Institute, Wuhan, began 6 months of molecular biology training at CSIRO Plant Industry with Dr Allan Green in midmid-November 2006. His project will involve cloning of a range of fatty acid biosynthesis genes from the *Crambe abyssinica* oilseed species.

CIM/2003/067: Ensuring productivity and food security through sustainable control of yellow rust of wheat in Asia

Multilateral

Overseas Collaborating Countries	Afghanistan, Bangladesh, China, India, Pakistan
Commissioned Organisation	International Maize and Wheat Improvement Center, Mexico
Project Leader	Dr Ravi Singh Phone: 52 55 58042004 Fax: 52 55 58047558 Email: r.singh@cgiar.org
Collaborating Institutions	University of Sydney, Australia International Center for Agricultural Research in the Dry Areas, Syria Global Overseas Collaborators, Global
Project Budget	$1,000,050
Project Duration	01/01/2005 to 31/12/2009
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Wheat is a widely grown crop throughout many parts of Asia. Of the total worldwide areas planted to wheat more than 40 per cent is grown in Asia where it is an important staple food crop. Of the 95 million hectares devoted to wheat cropping almost half this area (some 43 million hectares) is susceptible to stripe rust.

Stripe rust's causal agent, *Puccinia striiformis tritici (Pst)*, can spread rapidly. It is capable of air-borne migration being carried long distances by wind. The agent can also evolve rapidly into new wheat races (those of a common ancestry). Growing numbers of wheat races have proven susceptible to yellow rust. One wheat resistant gene, *Yr9*, present in several wheat races, in South, West and Central Asian countries has begun to break down, resulting in millions of dollars of losses from rust.

Current control measures, fungicides applied at the appropriate time in the cropping cycle, are adequate. These are, however, environmental and price constraints, as the chemical cause pollution and add to production costs. Growing new varieties with rust resistance is likely to produce the most successful control option, also addressing cost and environmental constraints. The ability of rust to travel distances, invade new races and break down resistant genes will require the identification and breeding of lines with a new genetic basis for resistance, the subject of this work.

The aim of this project is to increase the food security and profitability of wheat production systems in several countries of Asia and to protect the environment and human health through strategies contributing to the sustainable control of yellow rust disease of wheat.

Project Progress

Year 2 (01/01/2006–31/12/2006)

ACIAR funding supports ongoing and new research and capacity building activities at CIMMYT, ICARDA, and PBIC-Sydney University to ensure productivity and food security through sustainable control of wheat yellow rust, caused by *Puccinia striiformis tritici* (Pst), in Asia. Development of new near-isogenic lines (NIL) for greenhouse and field monitoring for genes Yr2, Yr3, Yr4, Yr33, Yr34, Yr35, Yr36 is progressing to fill the gaps in the existing NIL set. NIL for gene Yr8 have been purified and multiplied and for Yr17 purified. Specific gene combinations are also under progress.

Data from Yellow Rust Trap nurseries planted at key sites in South Asia, China and CWANA regions indicate significant variations in Pst populations in these areas. Virulence for Yr17, first detected in Central Asia, is now widely spread. Increasing virulence for Yr3 and its distribution in Pakistan and Afghanistan is a threat to the variety 'Tatara' the sown area of which has increased recently after the epidemic on 'Inquilab 91' during 2005.

Lack of virulence for some genes that were ineffective previously is a major concern to progress in yellow rust breeding. A unified Yellow Rust Trap Nursery will now be planted in all countries except China which forms a different epidemiologic region with very different cultivars.

Several facultative/winter wheat cultivars grown, or newly released, in various countries of the CWANA region indicated that only a few were resistant at all sites, except in Pakistan. This further demonstrated their vulnerability to diverse pathotypes predominant in different areas. Seedling gene postulation work on Central Asian cultivars conducted in Australia identified some of the commonly occurring genes, which have little or no value to provide resistance to some of the races known to occur in the region.

Evaluation in Mexico of individual F2 derived-F5 lines from crosses of yellow rust susceptible Avocet with four Chinese cultivars that show moderate levels of resistance in China but immunity in Mexico confirmed F3 results that each cultivar carried 1 major gene and 2–3 minor genes.

Significant progress was made in incorporating durable resistance into several cultivars from China. Because these Chinese cultivars are highly resistant in Mexico but either susceptible or moderately resistant in China, we used a shuttle breeding strategy to speed up the breeding as well as select under high yellow rust pressure in China.

During 2006 we identified 119 advanced lines with yellow rust resistance and desirable agronomic traits and planted them in replicated yield trials in farmers' fields during the 2006–07 season. Selections were done on 62 new BC1-derived-F5 populations involving 13 additional Chinese cultivars from Sichuan and Yunnan provinces during 2006 in Chengdu and over 1000 advanced lines were planted for further evaluation and selection during 2006–07. An additional 94 F4 populations were planted in Chengdu and Kunming following selection in the F2 and F3 generations in Mexico.

The '1st Elite Bread Wheat Yield Trial', containing 28 high-yielding entries with resistance to rusts, was grown at a total of 16 sites in India, Pakistan, Afghanistan, Iran and Turkey to find replacements for cultivars that are now susceptible to new races of yellow rust. Several new lines showed significantly higher yield potential and resistance at most of the sites in each country and were selected by the co-operators for further testing. Seed of high yielding entries for the '2nd Elite Bread Wheat Yield Trial' was multiplied during 2006 and planted at 30 sites in 11 countries. About half of the entries have shown high to moderate levels of resistance to the Ug99 race of stem rust pathogen.

Incorporation of yellow rust resistance in 21 facultative/winter wheat cultivars from Central Asian countries has been progressing well in Mexico. Populations in various generations from F1 to F3 were planted for either backcrossing or selection under yellow rust pressure in the 2006–2007 winter season at Toluca, Mexico.

A training course was organised in Uzbekistan for 20 scientists, mostly from Central Asia, to enhance their capacity in managing rust diseases of wheat and breeding for resistance. A Chinese scientist, Mr. Huazhong Zhu, attended a 3-month advanced training course on wheat improvement in Mexico. R.P. Singh, C. Wellings and A. Yahyaoui interacted with various scientists during visits to various breeding and pathology programs in China and Central Asia.

LWR/2002/032: Integrated manure nutrient management in soybean/wheat cropping systems on vertisols in Madhya Pradesh and Queensland

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	University of Queensland, School of Land and Food Sciences, Australia
Project Leader	Dr Neal Menzies Phone: 07 3365 2059 Email: N.Menzies@uq.edu.au
Collaborating Institutions	Indian Institute of Soil Science, India Department of Natural Resources and Mines, Queensland, Australia BAIF Development Research Foundation, India
Project Budget	$1,027,336
Project Duration	01/07/2004 to 30/06/2008
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

Madhya Pradesh is a major producer of soybean in India, but yields are only half what can reasonably be expected. Soy/wheat rotations dominate cropping, much of it on vertisol soils. These are soils with 30 per cent or more clay content, are predominately deeper than 120 cm, crack during dry seasons and shrink and swell in the region's monsoonal climate. Crop simulations and field experiments have shown soy yields should be around 2.4 t/ha, but most farmers struggle to achieve 1.2 t/ha.

An earlier ACIAR project surveyed nutrient needs and manure use in Madhya Pradesh, revealing a negative balance for nitrogen (N), phosphorus (P) and potassium (K). These negative nutrient balances are typical of Indian farming systems. Despite increases in fertiliser inputs the gap between inputs and nutrients removed remains relatively constant. A desktop study in the earlier research calculated cropping in Madhya Pradesh removed 1.6 million tonnes of N, P and K each year, but fertiliser inputs, manure and fixing of nitrogen by legumes replace only 0.7 million tonnes. Without inputs to reduce this gap, soils will continue to be depleted and result in lower yields until cropping is no longer sustainable. For poor farmers increases in inputs are best met through the more efficient use of farmyard manure (FYM). Most manure is used for fuel with limited use as fertiliser. Improving its use by addressing the efficiency of storage and use will allow better utilisation of a resource that can help to rebalance the nutrient gap.

In Queensland farmers using manure from feedlots as a nutrient supplement have experienced increases in nitrates and phosphorus, which which have the potential to pollute local waterways. The Australian component of the project will address more efficient resource use from the perspective of minimising pollution, applying these results in India. Major objectives are:

- to assess integrated nutrient management (INM) strategies for soybean / wheat systems (inorganic and FYM) and identify any agronomic constraints that may be restraining productivity in these systems
- to assess FYM production and characterise the benefits of FYM use in cropping systems
- to assess adverse environmental impact of FYM in fields and landscapes and develop an Environmental Audit framework for the safe utilisation of feedlot manure
- to develop practical tools and action-learning modules for nutrient management practice, including the most efficient utilisation of FYM.

Project progress

Year 3 (01/07/2006–30/06/2007)

Integrated nutrient management (the combination of nutrient supply from organic matter and inorganic fertilisers) trials were conducted for a second year in Raigarh and Bhopal districts (two replicated trials in each district).

Treatment regimes were developed to evaluate inorganic fertilisation, organic fertilisation, and a combination of inorganic fertiliser and organic fertilisation for the soybean/wheat cropping system. In the soybean season, the treatments used included inorganic N, P, K, S and Zn at recommended rates, 5 t FYM + 50% of the recommended rate of inorganic fertiliser, 5 t FYM + 50% inorganic fertiliser + rhizobium inoculation, and an organic matter treatment of 5 t FYM. Other treatments evaluated the effectiveness of phosphorus solubilising bacteria, and *Azotobacteria* (a free living N fixer). A farmers' practice treatment was also included.

The *Kharif* (monsoon season) soybean crop was adversely affected due to intense rainfall and flooding over much of Madhya Pradesh, and one of the project's experimental sites was lost. In the remaining three trials, the highest soybean grain yields were obtained in the 50% inorganic fertiliser + 5 t FYM + rhizobium (2.0 t soybeans/ha), with the 100% inorganic fertiliser treatment (1.8 t/ha) as the second highest performing treatment.

Similar results were obtained in 2005–2006, with the 100% inorganic fertiliser (2.1 t/ha), 50% inorganic + 5 t FYM (2.2 t/ha), and 50% inorganic + 5 t FYM + rhizobium inoculation (2.3 t/ha) producing yields which were not significantly different to each other, but significantly more than the other treatments tested (1.8 to 1.9 t/ha). An economic analysis (mean of two years 2005–06 and 2006–07) of the integrated nutrient management (INM) options in soybean revealed that the 50% inorganic fertiliser + 5 t FYM/ha + rhizobium to soybean produced the highest net returns (Rs13,457 /ha) and highest benefit:cost ratio (1.28:1) to the farmer.

In the wheat season, these same treatments also produced the best grain yields of 4.9 to 5.1 t/ha (the 100% inorganic fertiliser treatment again receiving the recommended rates of N, P, K, S and Zn, and the integrated nutrient management treatments receiving 75% of the recommended rate of inorganic fertiliser). This result was also obtained in 2005–2006, with yields of 4.8 to 5.0 t/ha obtained.

In both years, the organic fertilisation treatments, which received 8 t FYM prior to planting the wheat, and the farmers practice, produced significantly lower yields (around 4 t/ha). Economic analysis of INM treatments in wheat showed that the 100% inorganic fertiliser treatment produced the highest net returns (Rs. 48383 /ha) to the farmer, while the INM treatment, which only received 75% of the inorganic fertiliser produced the highest benefit:cost ratio of 4.4:1. As with soybean, both of these treatments produced higher net returns than the farmers' practice.

The INM option of 50% inorganic fertiliser + 5t FYM/ha + rhizobium to soybean and 75% inorganic fertiliser to wheat was found to be an economically viable, and culturally attractive, nutrient management option for small farmers. These farmers can easily produce 5 tonnes of farmyard manure per annum, and this is adequate for their small land area. In case of medium (2–10 ha) and large (>10 ha) land holdings, it may not be possible to cover the entire holding with the INM nutrient management strategy every year as the FYM available is not sufficient. These farmers are more likely to use the 100% inorganic fertilisation approach on part of their holding to sustain higher productivity of soybean–wheat system. However, during group meetings farmers stress the value of FYM, and all farmers will continue its use, at least on part of their land. Thus, there is a high level of willingness to adopt the more effective INM approaches developed in this project.

In the initial year of the project, omission trials were conducted in farmers' fields to determine if lack of nutrients, other than nitrogen and phosphorus which are routinely used by farmers, is limiting yields. This activity demonstrated responses to zinc and sulfur.

The nutrient omission trials proved to be effective in demonstrating these deficiencies, and farmers in the study area now realise the importance of these nutrients, and are applying gypsum or single superphosphate to supply sulfur, and zinc sulfate to supply zinc. The experimental approach of using nutrient omission trials at a farmer's field scale is relatively simple, and as the results are unambiguous, this is an effective extension tool. BAIF is interested in developing this approach further for more widespread use.

LWR/2004/033: Zero-tillage rice establishment and crop-weed dynamics in rice and wheat cropping systems in India and Australia

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	University of Adelaide, School of Agriculture and Wine, Australia
Project Leader	Dr Gurjeet Gill Phone: 08 8303 7744 Fax: 08 83037979 Email: gurjeet.gill@adelaide.edu.au
Collaborating Institutions	CCS Haryana Agricultural University, India Punjab Agricultural University, India International Maize and Wheat Improvement Center, India
Project Budget	$1,000,706
Project Duration	01/07/2006 to 30/06/2011
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

In India rice–wheat systems are planted extensively. One problem commonly encountered is degradation of soil structures, caused by excessive tillage and puddling of water for rice production. No-till systems for wheat, developed and introduced in past ACIAR research, have opened the way for no-till rice cropping. Preliminary research suggests no-till rice can also be grown, substantially boosting the benefits of no-till wheat that are often subsumed by tillage and puddling in rice cultivation. Improving the productivity of direct-seeded rice, including by weed and crop management improvements, will be undertaken to minimise the yield gap between wheat and rice.

Project Progress

Year 1 (01/07/2006–30/06/2007)

During 2006, significant progress was made against all project objectives, involving the collaborative efforts of the researchers from the institutes of CCS Haryana Agricultural University (HAU), Punjab Agricultural University (PAU), Rice-Wheat Consortium (RWC) and the University of Adelaide (UA), to investigate zero-tillage rice establishment and crop–weed dynamics in rice and wheat cropping systems of India and Australia.

Excellent progress has been made in the development of baseline information required for the successful establishment of direct-seeded rice (DSR) as a productive and sustainable alternative to the conventional hand-transplanted system. Several field sites (n=35) were established across states of Haryana, Punjab and Bihar.
These states geographically provide an excellent cross-section of the Indo-Gangetic plains in terms of climatic and productivity status. Consultation amongst principal scientists, researchers and growers from each region, identified local issues to be investigated within the proposed objectives of this project.

More specifically, key experimental questions addressed in the first year of the project for DSR systems included (*a*) direct validation of rice productivity in comparison to hand-transplanted puddle system, (*b*) identification of optimal rice sowing densities and times, (*c*) evaluation and suitability of different rice genotypes, (*d*) identification of weed recruitment/dynamics and potential shifts in weed flora, and (*e*) development of robust weed management strategies.

Comparative evaluation of DSR against the traditional hand-transplanted system showed a yield depression was associated with zero-tillage establishment in Punjab (20–73%), and Bihar (23%) sites, respectively. However, optimising sowing time and seeding rates (40–60 kg/ha) of rice significantly reduced the yield penalty associated with zero-tillage (=7%). Data from sites in Punjab and Bihar showed that rice yields were statistically non-significant between DSR and transplanted systems when sowing dates were similar for the systems.

The maturity profile (short versus long) of rice cultivars was also shown to be an important characteristic to final yield outcomes and requires further investigation.
In addition, grower field sites (n=17) were established in Haryana to evaluate the performance of basmati and coarse grain rice established under zero-till and puddle transplant systems. Preliminary data are extremely encouraging, showing similar yields for zero-till (2275 to 6800 kg/ha) and traditional puddle transplant systems (2325 to 7625 kg/ha). It is expected that ongoing interaction between the researchers and growers on alternative rice production systems will greatly facilitate the on-farm adoption of DSR.

Project scientists also focused on identifying suitable rice genotypes for DSR, with rice breeding lines and cultivars sourced from local breeding programs. Several genotypes (n=33) differing in maturity (short, medium & long) and vigour were evaluated under DSR and transplanted systems at sites in Punjab and Bihar. It was encouraging to note that some of the advanced breeding lines produced similar yields under DSR and transplanted systems. However, it is important that these data be revalidated in 2007, to show the effects of seasonal variation on these genotype sowing system responses. In 2007 it is anticipated that additional breeding lines will be sourced from the International Rice Research Institute (IRRI) and Indian breeding programs and evaluated for suitability under the DSR system.

An experiment undertaken in Bihar investigating weed establishment under DSR and transplanted rice showed that final weed densities (grassy, broadleaf and sedges) were similar for the different crop establishment systems (248–457 plants/m²). However, a significant shift in the weed spectrum resulted in fewer grassy weeds (48–83 plants/m²) establishing in zero-till DSR as compared to the transplanted system (220 plants/m²), respectively. Significant shifts in weed flora under DSR will have important implications for the management and the potential development of herbicide resistance. Research undertaken as part of the current project will closely monitor the resistance status of weeds under DSR.

Experiments evaluating different herbicide options for DSR identified useful mixtures (i.e. azimsulfuron + metsulfuron) for the control of broadleaf and sedge weeds. Useful options for controlling grass weeds in DSR were limited; however, herbicide Bispyribac provided excellent control (90%) of *Echinochloa crus-galli* (Barnyard grass) at sites in Haryana. High levels of weed control obtained with Bispyribac resulted in a 3–7 fold increase in rice yield in comparison with the weedy controls.

Extensive data were gathered from Australian experimental work, with collection of information on water- and nutrient-use efficiency in wide-row (WR) cropping under well-below-average growing season rainfall. In addition, replicated experiments were established to investigate the performance and suitability of different crop species and their cultivars to WR cropping.

These experiments have identified cultivars better suited to WR cropping and have consequently been repeated this year. Field experiments also investigated weed behaviour and management opportunities in WR cropping. Preliminary data have shown that WR systems appear less conducive to the establishment of problematic weeds such as annual ryegrass (ARG). Furthermore, strategic intra- and inter-row herbicide applications were shown to provide high levels of ARG control, and significant crop yield increases. Future research will investigate weed population dynamics in farmer fields under WR zero-till cropping systems.

LWR/2006/124: Fine-tuning the Happy Seeder technology for adoption in northwest India

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	Charles Sturt University, International Centre of Water for Food Security, Australia
Project Leader	Professor John Blackwell Phone: 02 6933 4937, 0427 225355 mobile Fax: 02 6933 2647 Email: jblackwell@csu.edu.au
Collaborating Institutions	International Rice Research Institute, India Punjab Agricultural University, India NSW Department of Primary Industries, Australia
Project Budget	$399,378
Project Duration	01/10/2007 to 30/09/2010
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

ACIAR project LWR/2000/089, Permanent beds for irrigated rice-wheat and alternative cropping systems in north-west India and south-east Australia, saw a breakthrough in the development of a new generation of seeders capable of direct-drilling wheat into heavy rice residue loads without prior burning of stubble. The machines were developed in collaboration with a machinery manufacturer and are called 'Happy Seeders'. The Happy Seeder is able to sow directly behind the combine harvester **in one operation**. It cuts and lifts the straw, presenting the seeding drill with clear soil, and then deposits the cut straw as a mulch on top of the sown seed or as a mulch between the seed rows. This technology (HST) provides an environmentally preferable alternative to burning and thus legislators are likely to encourage (or legislatively enforce) adoption of the technique.

Proof of concept was established primarily in controlled experiments on the PAU research farm, with some limited testing on farms of lead (and wealthier) farmers in the surrounds of Ludhiana. But appropriate recommendations for residue, nitrogen and irrigation management to go with the technology are lacking. In the absence of such crop management guidelines, there is a risk that the deployment of the HST will be machinery-driven and hence sub-optimal, in turn making the technology less attractive in the first place or leading to future discarding of the technique

Accordingly, the aim of this project is to reduce the environmental and health impacts of current practices and to sustain the profitability of rice–wheat cropping systems in NW India by enabling an accelerated roll-out of the Happy Seeder technology. Specific objectives are:

1. to assess and fine tune the Happy Seeder machines in on-farm experiments in collaboration with farmers, the machinery manufacturer and contractors
2. to optimise nitrogen x residue x irrigation management using the Happy Seeder approach on the major soil types of NW India
3. to disseminate the Happy Seeder technology in NW India
4. to assess the potential for the Happy Seeder technology in Australia.

Project Progress

First progress report due in 2008.

CIM/1996/025: Physiological and genetic approaches for the development of waterlogging tolerance in wheat on sodic/alkaline and neutral soils in India and Australia

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	Agriculture, Western Australia, Australia
Project Leader	Dr Tim Setter Phone: 08 9368 3289, 08 9368 3333 Fax: 08 9474 2840 Email: tsetter@agric.wa.gov.au
Collaborating Institutions	University of Western Australia, Australia Central Soil Salinity Research Institute, India ND University of Agricultural Technology, India Directorate of Wheat Research, India Department of Primary Industries, Victoria, Australia
Project Budget	$931,426
Project Duration	01/01/2001 to 30/06/2007 (Project extended from 01/01/2005 to 30/06/2007)
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Waterlogged soil damages plants as the water inhibits the exchange of oxygen and carbon dioxide between the roots and the atmosphere. In addition, the activity of soil microbes in the anaerobic environment then changes the soil chemistry, which in turn alters nutrient availability and releases potentially toxic substances. Different soil types may react differently. After water-logging, there is often less nitrogen available and this may limit recovery in some situations.

Plant species vary considerably in their ability to tolerate the oxygen deficiency and the soil chemistry aspects of water-logging. This large genetic variation means that there is considerable potential for improving the tolerance of crops to water-logging. Even within agricultural species, there is wide variation. Genetic evaluations of wheat crosses have shown that the heritability of water-logging tolerance is quite high.

Water-logging is common in parts of India on sodic soils. Unless physically drained, wheat plants may remain submerged for up to 10 days or more, completely killing intolerant varieties and resulting in large losses. In Australia the problem often occurs on duplex soils, although sodic soils in parts of Western Australia and Victoria can be affected. Again, losses occur; for every 10 mm additional rainfall in August in one district of WA, productivity fell by about 150 kg of wheat per hectare.

A few water-logging-tolerant cultivars of wheat are known. This project is determining the mechanisms of tolerance in wheat, aiming to produce tolerant breeding lines by pooling traits in suitable germplasm for use in both countries.

The major objective is to produce breeding lines of wheat for Australia and India that are tolerant of water-logging on the main soil types prone to this cropping constraint in the two countries.

Project Outcomes

Final report not yet submitted by the Commissioned Organisation.

CIM/2001/026: Drying systems to improve grain quality in north-east India

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	University of New South Wales, Department of Food Science and Technology, Australia
Project Leader	Dr Robert Driscoll Phone: 02 93854355 Fax: 02 93855937 Email: r.driscoll@unsw.edu.au
Collaborating Institutions	Central Mechanical Engineering Research Institute, Power Engineering and Heat Transfer Group, India
Project Budget	$546,013
Project Duration	01/07/2003 to 31/12/2006
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Effective grain drying is essential in south Asia's monsoon belt. In India's West Bengal region drying of maize and rice is important for short-term food security. Seed is used for food and also for feeding animals, a vital source of draught power. Longer term security through ensuring feeds for following crops and for sale to increase income is dependent on maximising harvested seeds in a humid environment where spoilage is common. Static yields and low prices mean that even small reductions of postharvest losses can translate into significant additional security and income. Storage of surplus grains until periods of shortage when prices are higher only provides income if the grain is of sufficient quality. Current grain drying systems are based on technology that is up to 20 years old. This is inefficient, both in terms of dried grain quality and also energy inputs. Exacerbating these problems are losses during storage and transport, mainly from inattention to moisture removal. The resulting losses can be 20 per cent or more of production.

Enhancing the technology used could substantially improve grain industry efficiency and profitability, especially for smallholders. A major barrier to enhancing grain drying has been the use of inappropriate systems and technologies. The poor match of these to the agri-ecological conditions, characterised by monsoonal rains and humidity, has been a key failing.

The relatively poor levels of local understanding of moisture intake of grains and inability to engage local involvement have furthered this mismatch. As a consequence sun drying, being both labour- and land-intensive, is still widely used, during harvest and periodically during storage. The risks of spoilage and contamination are high, such as aflatoxin in dried maize to be used as stock feeds. Mechanical drying is a better option, with some small-scale adoption already under way. However few smallholders are in a position to adopt this without support, which comes mainly from NGOs.

Local seed processors are well placed to take up the improved technology and are being supported by the scoping, development and dissemination of better systems for grain drying under the humid topical conditions of South Asia.

Project Outcomes

Final report not yet submitted by the Commissioned Organisation.

FIS/2005/176: Masterclass – Aquaculture Nutrition Master Class

Bilateral

Overseas Collaborating Countries	India, Indonesia, Laos, Vietnam
Commissioned Organisation	Crawford Fund for International Agricultural Research, Australia
Project Leader	Dr Paul Ferrar Phone: (02) 61614842 Email: pferrar@netspeed.com.au
Project Budget	$50,000
Project Duration	01/05/2006 to 30/06/2006
ACIAR Research Program Manager	Mr Barney Smith

Project background and objectives

Small scale aquaculture in some developing countries is providing an important source of protein to supplement otherwise meagre diets. It is therefore important to have an understanding of fish nutrition and how to produce cost-effective aquafeeds by utilising locally available agricultural products.

This live-in two week intensive course for invited participants from Southeast Asia and Pacific Island countries offered comprehensive training in the following aspects of grow-out aquaculture nutrition: Principles of Aquaculture Nutrition; Introduction to Diet Formulation; Pelleting and Extrusion of Commercial Feeds; Natural Feeds and Integrated Aquaculture: Analytical Techniques; Potential Feed Ingredients; Farm Made and Laboratory Feeds; Feed Management; Feeding Strategies; Research Methods. Topics were presented as lectures, practical laboratory tutorials, discussion and revision sessions with field trips to farms and feed mills. Course material included lecture notes, text books and bibliographic literature.

Project outcomes

The ATSE Crawford Fund Aquaculture Nutrition Master Class was held at the Asian Institute of Technology, Bangkok, from 7 to 19 August 2006. The two week live-in intensive course for 27 invited participants from 10 Southeast Asian and Pacific Island countries offered comprehensive training in all aspects of grow-out aquaculture nutrition. Fourteen guest lecturers (seven from Australia and seven from other countries), delivered lectures and conducted practical laboratory tutorials followed by discussion and revision sessions and enhanced by field trips to farms and feed mills.

All participants had their travel, accommodation and other expenses paid for by the Master Class and in addition students were provided with extensive reading material, T-shirts and satchels. Student feedback from the course evaluation survey was very complimentary and most found the standard of content and delivery to be outstanding. This intensive two-week course will be condensed and repackaged as short 3-day workshops providing a summary of topics covered at the longer Master Class or covering a selection of key topics of particular interest to target audiences. For example, the first of these mini-workshops will be delivered in Papua New Guinea in November this year by two students and two lecturers from the inaugural Master Class and will focus on small-scale feed manufacture.

The success of the Aquaculture Nutrition Master Class can be attributed to a number of factors including the close working relationship and good humoured camaraderie of lecturers that resulted in the compilation of a well-rounded and comprehensive program; the mutual respect and admiration that developed between lecturers and students from vastly different backgrounds resulting in friendships being forged; the cooperative and collegiate attitude of organisations like NACA, AIT and ACIAR working together to ensure the Master Class achieved its primary aim.

In acknowledging that small-scale aquaculture in some developing countries is an important source of protein to supplement otherwise meagre diets, the Master Class aims to equip students with the basic understanding and importance of fish nutrition and how to produce cost-effective aquafeeds by utilising locally available agricultural ingredients.

HORT/2002/030: Improving sub tropical citrus production in Sikkim and Australia

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	Queensland Department of Primary Industries and Fisheries, Bundaberg Research Station, Australia
Project Leader	Mr Malcolm Smith Phone: 07 41556244 Fax: 07 41556129 Email: malcolm.smith@dpi.qld.gov.au
Collaborating Institutions	Sikkim Development Foundation, India Department of Agriculture, Fisheries and Forestry, Australia Queensland Herbarium (BRI), Australia
Project Budget	$399,366
Project Duration	01/01/2003 to 31/12/2006 (Project extended from 01/01/2006 to 31/12/2006)
ACIAR Research Program Manager	Mr Les Baxter

Project background and objectives

The Indian Himalayan state of Sikkim once had a thriving mandarin industry. However, production has been declining for several decades and yields are now less than 10 per cent of those in Australia. The decline may be partly due to disease (especially the bacterial disease known as huanglongbing) and the very narrow genetic base of the industry. Attempts to increase productivity through improved nutrition, disease eradication, vector control and the provision of clean planting material have been unsuccessful. Although large-scale orchards can control disease through vector control and the use of clean planting materials, these methods are too expensive and difficult for small farmers.

Germplasm evaluation and improvement are a fundamental component of modern citriculture, but have received limited attention in the Indian Himalayas. Extensive genetic diversity exists within *Citrus* and related genera, and this could be exploited to select disease-resistant genotypes suitable for local conditions that would help to increase mandarin yields and profitability for small farmers. Despite existing problems, citrus remains the most important horticultural crop for Sikkim, and there is a large and lucrative market that could be captured if productivity increased.

This project is improving subtropical citrus productivity in the state of Sikkim by introducing improved germplasm for hardier, more vigorous plants, with greater disease resistance than existing plants.

Project outcomes

The project obtained proof that disease was the major impediment to the citrus industry in Sikkim, and the project team used the evidence generated to build consensus from initially disparate views. This recognition of a single major factor obstructing citrus productivity in the region is fundamental to improving the current poor state of commercial orchards, and ensuring the limited resources (both R&D, and farm-level inputs) are not further wasted on activities that offer no prospect of success.

Leaf samples collected at all survey sites in all three years, prepared within Sikkim and then transferred (under quarantine approval) for molecular analysis in Australia consistently showed a high incidence of the bacterial disease huanglongbing (HLB). At a socio-economic level, the survey established that farmers had a strong desire to grow citrus as it was their most profitable crop with substantial market demand.

The survey material also proved valuable in the development of a diagnostic protocol for HLB testing in Australia. The disease and its vector (the Asiatic citrus psyllid) are currently exotic to Australia and preparedness for incursion of either is a major concern for the Australian citrus industry. A strong diagnostic protocol is one important component of the incursion management strategy, and this project provided the material to assist in its development.

The project also provided new information regarding the susceptibility of Australian citrus relatives to another important exotic disease, citrus canker, at a time when it was dealing with an outbreak near Emerald in central Queensland. Knowledge of whether native plants can be hosts is essential to disease management, and particularly disease eradication programs. Work from this project identified a number of new hosts of citrus canker including species that were assumed resistant (on the basis of their close relatedness to other non-hosts).

The results demonstrate the hazard of using taxonomic proximity to predict disease status and provided the Emerald canker eradication program with concise information on the species that could host citrus canker. This had important practical implications for the eradication program – even if the knowledge of a new host plant was not always welcome news.

Improved germplasm has been fundamental in overcoming destructive citrus diseases in the past, and germplasm evaluation activities formed a major component of this project. This project successfully introduced over 100 citrus genotypes to Sikkim, all of which are now growing successfully and awaiting evaluation. This represents an important resource for citrus farmers of the Himalayan region and has the potential to generate practical improvements to their farming system well into the future. It also represents an important scientific resource as the disease reaction of this diverse germplasm, particularly to HLB, has never been evaluated.

For the first time rootstock evaluation experiments were propagated and established in Sikkim using the locally preferred scion variety. Further impacts and practical benefits of this project activity will be evident as these trees commence fruit production.

Within Australia, the project established extensive rootstock experiments with both Eureka lemon and Imperial mandarin – until then rootstock research in temperate conditions had been very limited. The lemon experiment has already demonstrated a significant impact of rootstock on skin texture – one of the major quality attributes limiting Australian lemons on the international market. The work also demonstrated the relative poor quality of one of the rootstocks commonly used commercially, and identified two new rootstocks that offer improved nursery performance, yield and fruit quality.

Australian/PNG native citrus species had often been touted as potential rootstocks for citriculture but the research field work had never been done. This project finally put these species to the test. Unfortunately, all species proved highly susceptible to citrus tristeza virus (CTV) and would need to be hybridised to overcome this constraint.

The Imperial mandarin rootstock experiment generated by this project has also produced useful outcomes, despite its young age. This experiment included non-conventional germplasm as well as promising new rootstock genotypes from breeding programs in different parts of the world. It also included the Chinese germplasm introduced to Australia under a previous ACIAR project – the first time it had been evaluated under subtropical conditions.

One rootstock variety that had performed well in research in NZ was found highly sensitive to Australian strains of CTV – trees on this rootstock declined and died shortly after field planting. Such information has significant practical implications in preventing commercial investment in this ‘promising’ rootstock, and it also emphasises the need for germplasm evaluation under local conditions prior to commercial planting.

Good nursery practice is essential to a viable citrus industry. This is particularly the case where graft-transmissible diseases, such as HLB, are endemic. For this reason the project conducted budding workshops for citrus farmers in different parts of Sikkim. Prior to the project all trees were grown from seed which meant that it was at least seven years before any fruit was produced. Survey results also demonstrated that these seedling trees became infected with HLB during the nursery phase – meaning that farmers received trees that not only took many years to fruit but already carried HLB.

The nursery workshops focused on practical means of reducing disease incidence, and by using superior budlines (identified and tested free of HLB by the project team) offered the prospect of commercial quantities of fruit within a few years of planting. Nursery facilities established by the project represent a significant improvement over previous production systems and are already providing farmers with improved planting material.

The project has had an important impact in improving the status of farmers. Prior to the project, farmers carried much of the blame for the poor state of the citrus industry in Sikkim. The project provided proof that the decline of orchards was disease-related, and not due to poor management. The efforts of the project team helped to build consensus around this discovery, and brought a new-found respect for citrus farmers and for the enormous obstacle they faced in managing HLB.

LWR/2000/089: Permanent beds for irrigated rice-wheat and alternative cropping systems in north-west India and south-east Australia

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	CSIRO Land and Water, Australia
Project Leader	Dr Elizabeth Humphreys Phone: +63 (2) 580 5600 ext: 2342, 0400 601 528 Fax: +63 (2) 580 5699 Email: e.humphreys@cgiar.org
Collaborating Institutions	NSW Department of Primary Industries, Australia Punjab Agricultural University, India
Project Budget	$1,712,993
Project Duration	01/01/2002 to 31/12/2006
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

Conventional flooded and puddled rice systems on flat land are detrimental to the growth of post-rice crops, and also require enormous amounts of energy for tillage in switching between rice and wheat crops. Permanent beds are a radical change in practice, offering the possibility of providing and maintaining suitable soil conditions for the growth of both rice and wheat crops in the rotation, increased cropping flexibility, minimum tillage, increased water-use efficiency and reduced deep percolation losses.

Over the past three decades, rice-wheat cropping has assumed vital significance in the Indo-Gangetic Plains (IGP) and in India in particular. But there are major economic and environmental threats to agricultural sustainability, including groundwater depletion, water-logging and salinity, deteriorating soil physical conditions, declining soil organic matter content, contamination of groundwater and atmospheric pollution.

The sustainability of irrigated agriculture in the rice-growing areas of southern Australia is also threatened by salinisation as a result of rising watertables. The availability of water for irrigation is decreasing (largely due to allocation of water for the environment) while its price is increasing, and the amount of water available for irrigation each year is uncertain.

The project is increasing the sustainability, yield, resource-use efficiency and profitability of the rice-wheat systems of the Indo-Gangetic Plain and of the cropping systems in the rice-growing areas of Australia, using permanent beds to improve soil, water and nutrient management.

Project outcomes

Final report not yet submitted by the Commissioned Organisation.

LWR/2005/059: Modelling water and solute processes and scenarios for optimisation of permanent raised bed systems in China, India, Pakistan and Indonesia

Bilateral

Overseas Collaborating Countries	China, India, Indonesia, Pakistan
Commissioned Organisation	CSIRO Land and Water, Australia
Project Leader	Dr Freeman Cook Phone: (07) 3214 2840, Mob: 0409 613 932 Fax: (07) 3214 2855 Email: freeman.cook@csiro.au
Project Budget	$84,816
Project Duration	01/04/2006 to 30/09/2007 (Project extended from 01/07/2007 to 30/09/2007)
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

Permanent raised beds are being used to minimise the effects of water logging, reduce irrigation water and improve the biological and physical health of the soils; all these factors leading to increased productivity of crops. Design criteria for permanent beds in terms of infiltration and drainage are not well developed and are usually driven by machinery specifications. Fertiliser placement for nutrient and solute management and the risk of build-up of salts are additional criteria to be addressed by country partners.

This project will underpin existing ACIAR projects by helping develop design criteria for optimising bed design from analytical and numerical modelling of water and solute transport; design fertiliser placement strategies to maximise fertiliser usage and minimise leaching to ground water; and determine whether salinisation is likely with time in some soil/bed configuration/climate/water quality scenarios. This will be done using two-dimensional water and solute modelling.

Project Outcomes

Final report not yet submitted by the Commissioned Organisation.

7.2 Subprogram 2: Water management for enhanced livelihoods in rain-fed areas of the Central Plateau, with emphasis on Andhra Pradesh.

Projects:

Active	
AH/2002/038	Improved productivity, profitability and sustainability of sheep production in Maharashtra, India through genetically enhanced prolificacy, growth and parasite resistance
CIM/1999/062	Improving the quality of pearl millet residues for livestock
LWR/2001/014	Improving water resource management in India's agriculture: Search for effective institutional arrangements and policy frameworks
LWR/2002/100	Water harvesting and better cropping systems for the benefit of small farmers in watersheds of the East India Plateau
LWR/2003/026	Water allocation in the Krishna River Basin to improve water productivity in agriculture
Concluded	
LWR/2006/045	Modelling minimum residue thresholds for soil conservation benefits in tropical, semi arid cropping systems
Pipeline	
LWR/2006/072	Assessing the hydrologic and socio-economic impact of watershed development in Andhra Pradesh (India) and the Murrumbidgee Irrigation Area (Australia)
LWR/2006/073	Feasibility of using medium range seasonal climate forecasting to improve crop production in Andhra Pradesh, India
LWR/2006/158	Enhancing institutional performance in water resource development in Andhra Pradesh, India

AH/2002/038: Improved productivity, profitability and sustainability of sheep production in Maharashtra, India through genetically enhanced prolificacy, growth and parasite resistance

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	University of New England, School of Rural Science and Agriculture, Australia
Project Leader	Dr Stephen Walkden-Brown Phone: 02 6773 5152 Fax: 02 6773 3922 Email: swalkden@metz.une.edu.au
Collaborating Institutions	Nimbkar Agricultural Research Institute, Animal Husbandry Division, India National Chemical Laboratory, Division of Biochemical Sciences, India University of Melbourne, Centre for Animal Biotechnology, Australia
Project Budget	$557,636
Project Duration	01/01/2003 to 31/12/2007 (Project extended from 01/01/2006 to 31/12/2007)
ACIAR Research Program Manager	Dr Peter Rolfe

Project background and objectives

It is a high priority of the state and national Governments of India to increase production of sheep meat and other livestock products to meet the growing demand for meat by the Indian population. Another priority is to increase supply of meat at reasonable prices in the rural, less affluent sections of society. This project aims to consolidate and fieldfield-test, under shepherd management, the improved reproductive rate and parasite resistance of Decanni sheep, using genes that have been introduced from other Indian breeds as a result of earlier ACIAR-funded research.

A major finding of the earlier project was that the Australian Booroola fecundity (prolific) gene seems to have originated in the Garole sheep from the Sundabans in eastern India. The Garole also has considerable resistance to *Haemonchus contortus*, the predominant parasite of sheep in India and Australia. This project will produce and test appropriate genotypes and develop extension models to assist the poorer shepherd communities of Maharashstra.

Project Progress

Year 4 (01/01/2006–31/12/2006)

Objective A: Ongoing production of appropriate genotypes for testing in shepherds' flocks.

During 2006, two artificial insemination (AI) programs were carried out in the NARI sheep flock; 531 ewes were inseminated, 356 ewes lambed, 486 lambs were born and 421 were weaned. The average litter size of the NARI flock increased from 1.2 in February to 1.5 in September 2006. Twenty-six rams were used in the first program; nineteen of these and an additional fifteen young rams were used in the second program.

The primary selection of rams and ewes was done using a selection index of EBVs for reproduction and growth traits. Conformation and facial features preferred by local shepherds were also considered as selection criteria. Allotment of rams to ewes (mate selection) was done using the TGRM program to maximise genetic merit while minimising relationships in the flock.

During the year, 263 DNA samples from NARI and 107 from shepherds' flocks were genotyped by NARI and NCL staff members jointly.

All lambing records at NARI since 1996 were analysed (3912 records of FecB+/FecB+ ewes, 1167 of FecBB/FecB+ ewes and 37 of FecBB/FecBB ewes).

The number of lambs born alive and weaned per ewe inseminated (and per ewe lambed) was estimated to be 0.97 and 0.90 (1.02 and 0.95) for FecB+/FecB+ ewes, 1.43 and 1.24 (1.56 and 1.35) for FecBB/FecB+ ewes and 1.63 and 1.33 (1.72 and 1.40) for FecBB/FecBB ewes. At the end of 2006 there are 510 ewes available for breeding. For the first time, more of these (i.e. 270) are FecBB/FecB+ ewes than FecB+/FecB+ ewes (200) and there are 40 FecBB/FecBB ewes.

A nucleus Garole flock of 58 ewes and 40 rams is being maintained at NARI. Sixty-seven new lambs were born during December 2006 and 57 of these (24 males and 33 females) were alive at the end of 2006. The Garoles have now adapted well to conditions at NARI.

Objective B: Ongoing dissemination of improved FecB carrier rams and semen into shepherds' flocks and evaluation of performance data.

Ten homozygous and two heterozygous FecB carrier rams were introduced into eight shepherd flocks for breeding. Oestrus synchronisation and artificial insemination were carried out using homozygous FecB carrier ram semen in nine flocks. These flocks with 818 ewes in total are intensively monitored. Additionally, 11 FecB carrier rams were introduced into 11 'less intensively monitored' flocks with 442 breeding ewes in total.

NARI's rams have sired total 260 lambs in these flocks during the year, lambing is in progress in six flocks and will commence in the next two months in six flocks. The proportion of FecB carrier adult breeding ewes in intensively monitored participating flocks has increased from 13 to 20% over the reporting period. The number of lambs born alive and weaned per ewe lambing was 1.02 and 0.92 for FecB+/FecB+ ewes and 1.48 and 1.09 for FecBB/FecB+ ewes in 16 flocks. The figures for 10 of these flocks which were better managed were similar for FecB+/FecB+ ewes but for FecBB/FecB+ ewes, they were 1.55 lambs born and 1.26 lambs weaned per ewe lambing.

Four workshops were conducted at NARI's Lundy farm for dissemination of project results with about 25 shepherds participating in each one. The workshops were organised when there were 2–3 month old lambs in the NARI flock to show to the shepherds how the ewes and lambs are managed at NARI.

NARI organised a workshop on 'Harnessing genetics to increase productivity of sheep and Bluetongue disease of sheep' on 8 November 2006. Around 500 shepherds attended. Ms. Leena Mehendale, Principal Secretary of the Animal Husbandry Department of Government of Maharashtra inaugurated the workshop.

A meeting of 60 government animal husbandry officers from the 32 districts of Maharashtra State organised in Pune by the Commissioner, Animal Husbandry was addressed by Dr. Pradip Ghalsasi. He informed them about the effect of the FecB gene on the reproductive performance of the two new strains of sheep being developed at NARI and the proper way to manage carrier ewes with a higher twinning percentage than the Deccani.

Objective C: Socio-economic analysis of the FecB dissemination program implemented in local smallholder flocks from 2003-06.

A draft survey questionnaire was prepared in September 2006 for interviewing the shepherd households where FecB carrier rams/semen and/or ewes were introduced. The questionnaire was modified by NARI researchers, translated into Marathi and nine of the participating shepherds were interviewed from November 2006 to January 2007. Shepherds' general perception is that they can get one and a half times as much income if a ewe has twin lambs rather than a single. They realize, however, that extra feed has to be given to twin-bearing ewes and to twin-born lambs.

CIM/1999/062: Improving the quality of pearl millet residues for livestock

Multilateral

Overseas Collaborating Countries	India
Commissioned Organisation	International Crops Research Institute for the Semi Arid Tropics, India
Project Leader	Dr C Tom Hash Phone: 91 40 2329 6161 ext 2322 Fax: 91 40 2324 1239 Email: c.t.hash@cgiar.org
Collaborating Institutions	International Livestock Research Institute, India
Project Budget	$1,220,014
Project Duration	01/01/2004 to 30/06/2009 (Project extended from 01/01/2009 to 30/06/2009)
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

In dry rainfed parts of India integrated crop-livestock production systems are the norm. In such areas pearl millet is the only cereal with a reliable production output. Pearl millet stover is the major component of ruminant diets in these production systems. More than 9 million hectares are sown to pearl millet with more than two thirds using hybrid seed.

Smallholder farmers are the main users and purchasers of hybrid seeds, to produce crop stover for use as green fodder. This has given rise to a whole system of growing and selling hybrid pearl millet seed. Stover yields and quality are, however, low when using these seeds. Farm practices to improve quality are considered risky in the highly unpredictable climates where most pearl millet is grown, negating their use to boost yield.

Livestock productivity is also low, in part due to the low quality and yields of millet for use as stover. Low quality and quantity outputs result in poor nutritional uptake by animals, mainly used for dairying. Attention is now being turned to improving stover quality, to increase nutritional uptake and also yields. ICRISAT is the major supplier of new pearl millet lines to the private sector, so is ideally placed to ensure the delivery of improved varieties to smallholders through the existing hybrid production system.

The major project objective is to improve smallholder livestock production in arid and semi-arid production systems in India; pearl millet hybrids with better inherent stover quality will be introduced.

Project Progress

Year 3 (01/01/2006–31/12/2006)

Annual report not yet submitted by the Commissioned Organisation.

LWR/2001/014: Improving water resource management in India's agriculture: Search for effective institutional arrangements and policy frameworks

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	La Trobe University, School of Business, Australia
Project Leader	Dr Lin Crase Phone: (02) 60249834 Fax: (02) 6058-3833 Email: l.crase@latrobe.edu.au
Collaborating Institutions	Indian Institute of Management, India University of South Australia, Australia Deakin University, Australia
Project Budget	$401,337
Project Duration	01/07/2002 to 31/12/2007 (Project extended from 01/07/2005 to 31/12/2007)
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

Water resource management is critically important in India because of the growing demand for food and because the incomes and employment of 60–70 per cent of Indians depend on agriculture. Irrigation is a key feature of India's agricultural strategy, but it is not being used to its potential. In fact, the excessive and indiscriminate use of water has often resulted in substantial harm to the soil and reduced productivity.

Unfortunately, water resource management in India is suffering. Surface water management requires heavy investment including meeting technical needs and environmental concerns. Groundwater management must reduce excessive pumping and address inadequate recharge of the watertable. There are simple, well-known technical and economic solutions to the problems, but institutional arrangements are complex and need support. There is an urgent need to develop better and more socially acceptable institutional arrangements.

In the past 15 years, Australian water managers have accumulated a wealth of information on water institutions and legal reforms. As in India, Australian water management institutions must deal with several levels of government as well as different types of water use and water users. The lessons learned from the Australian experience are expected to be applicable to the Indian situation.

The project is identifying institutions and policies that will promote the efficient and sustainable management of water resources in India.

Project Progress

Year 5 (01/07/2006–30/06/2007)

The initial project concluded in June 2006 and was reviewed by Dr Alistair Watson. Important observations from the review include:

- the project was well-grounded and had a clear focus
- the project objectives were broadly met, with some scope for enhancement in the context of objectives 1, 3 and 6
- the community impacts of the project are tied to a broader process of policy change in India. Whilst not understating the formidable political challenges ahead, the reviewer noted that the benefits of achieving sensible policy adjustments can be substantial, and in this context the project played a valuable part
- the capacity building and scientific impacts of the project had been significant
- project execution had led to useful cooperation between participants.

In addition to these general findings, the review proffered several mechanisms for extending the existing work. More specifically, three direct developments were recommended in the form of:

- publication of a book
- further dissemination via journal and feature articles targeted at influencing Indian opinion
- provision of survey data to other researchers.

A formal extension proposal was accepted by ACIAR to deliver on the above activities. During this reporting period draft chapters of the book manuscript have been prepared and additional journal articles submitted for publication. The data set developed as part of the project has also been made available to other scholars and those interested in this work.

The extension proposal also foreshadowed additional dissemination activities in India. These activities have stalled, primarily in an effort to leverage any visits into other work being developed by ACIAR under the theme of Watershed Development.

LWR/2002/100: Water harvesting and better cropping systems for the benefit of small farmers in watersheds of the East India Plateau

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	University of Western Sydney, Australia
Project Leader	Dr Peter Cornish Phone: 02 4570 1376 Fax: 02 4570 1684 Email: p.cornish@uws.edu.au
Collaborating Institutions	PRADAN, India Australian National University, Australia ICAR Research Complex for Eastern Region, India
Project Budget	$860,001
Project Duration	01/10/2005 to 30/09/2009
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

The East Indian Plateau comprises much of the state of Jharkhand and parts of adjoining West Bengal, Bihar and Orissa with a population of 27 million from which 78% is rural.The region is characterised by high but variable annual rainfall, from 1100 to 1600 mm, mainly distributed between June and September with frequent dry spells within the monsoon, little irrigation (therefore little non-monsoon cropping), high runoff and soil erosion, mono-cropped paddy lands, high tribal population, and subsistence agriculture with most villagers achieving only ~60% food requirement.

High rainfall yet low cropping intensity (one crop/year on cropped land) and dry periods indicate the need to improve the livelihoods of poor villagers through watershed development that may reduce the risks, and improve the returns from investment in improved technology. Watershed development which is a high priority for the Indian government has been restricted until now to semi-arid and arid tropics. This study will extend watershed development into the higher-rainfall East Indian Plateau in a collaborative project with the NGO PRADAN and the ICAR Research Complex for Eastern Region at Ranchi, Jharkhand and in partnership with the villagers of Purulia District, West Bengal.

The aim is to develop opportunities (viz. nutrient management, tillage, crop diversification and watershed management) in line with India-ACIAR priorities. The objective is to develop principles and evaluate potential hydrologic impacts of water harvesting for the parallel improvement of food/nutritional security and income of the farmers in India.

The specific objectives of the project are to:

- develop, validate and promote water harvesting principles
- make a preliminary assessment of the applicability and sustainability of water harvesting across the East India Plateau, through hydrologic and geo-hydrologic studies
- develop cropping system options and improved agronomy to effectively use harvested water
- evaluate biophysical and socioeconomic impacts
- enhance the capacity of PRADAN and NGOs to undertake watershed development work.

Project Progress

Year 1 (01/10/2005–30/09/2006)

The project commenced on 1 April, 2006. Activities within each of five project objectives include:

1. Develop, validate and promote water harvesting principles

The basis of WSD, as practiced by the NGO partner, PRADAN, is social development through self-help groups, a process which has commenced and will proceed throughout the project.

The first step towards a watershed development plan is to understand the resources available and any constraints to development. PRADAN is undertaking socioeconomic 'mapping', and other team members are focused on the biophysical assessment.

Soil and landscape assessment within the case study watershed (Pogro) has focused on: *a*) soil descriptions and classification, with 12 soil pits completed, representing the major landscape units and variation within them; *b*) surface soil sampling and analysis for fertility assessment within each of the main landscape units (~100 sites in Pogro watershed, and in Amagara where agronomic work will be located initially), with the partially completed analyses revealing higher pH than expected for this region (lowland mean pH 7.2, medium lowland 6.0 and uplands 5.5) but consistent with observations of annual *Medicago* spp., and indicating organic carbon is low at all locations (0.6–0.7%) as with exchangeable potassium; *c*) water resource assessment using EM38 and EM31 electromagnetic induction, with watershed maps of conductivity having been produced and instrument calibration proceeding to convert this to estimates of profile water.

PRADAN has produced a 'resource map' of the Pogro watershed. All data will be georeferenced and mapped onto cadastral maps (scanned into ArcView) or a topographic map which has been created in ArcView from our GPS.

Work has just commenced on developing databases of climate and hydrology for subsequent modelling purposes. In Pogro, baseline hydrologic conditions are being established through gauging surface flow at the outlet by placing gauges on the wall of two culverts and training a local farmer to take readings as required. Thirteen piezometers have been installed for monitoring shallow groundwater, and water levels in seven wells are also being monitored, as well as water levels in four 'ponds' in which staff gauges have been located.

A conceptual model for hydrology of small watersheds has been developed that could form the basis for modelling from which criteria ('thumb rules') can be developed to either assess the suitability of small watersheds for development or to plan, design and install water harvesting measures. Fill rate tests have been conducted on bore holes as a first step to develop design principles for 'seepage tanks'.

2. Make a preliminary assessment of the applicability and sustainability of water harvesting across the East India Plateau.

The first step has been to review hydrologic and geo-hydrologic models.

3. Develop cropping system options and improved agronomy to effectively use harvested water.

Participatory workshops and other activities led to a set of issues where the objectives of the project and farmers coincided. Three action-learning fertiliser workshops (75 farmers) followed, which included subsequent on-farm experiences. Planning for this 'experience', together with earlier workshops, led to agreed experiments evaluating maize, black gram, upland rice and finger millet as alternative crops for upland areas and poorer upland paddy, all with fertiliser treatments, and to evaluation of fertiliser responses on kharif rice.

In Amagara, rice of three different durations was planted as the commencement of a cropping systems experiment that evaluates the opportunities and costs associated with shorter duration rice varieties, which has emerged as a central theme for the agronomy/farming systems work. Other experiments explored the growing of early season vegetables, but the focus here is on the change process amongst farmers.

In all, more than 90 farmers have been involved in the design, implementation and management of these trials, all of which are replicated across farmer's fields. Harvest has not been completed, but already it is clear that there are very large responses to P in all crops, to K in legumes, and to N in non-leguminous crops. Native rhizobia appear to be effective on the legumes examined.

4. Evaluate biophysical and socioeconomic impacts.

A workshop was held in Toowoomba, involving most team members (eight from India). The program comprised a participatory evaluation process and development of a framework with a set of indicators.

5. Enhance the capacity of PRADAN (and other NGOs) to undertake watershed development.

PRADAN has been exposed to new ways of conducting on-farm investigations which should involve no more resources but provide much better information. Rigorous evaluation of all activities has been implemented, to introduce greater discipline into the (continuous) learning process. New crop options have been collaboratively developed for evaluation. PRADAN has been exposed to GIS, which may be introduced into broader activities.

LWR/2003/026: Water allocation in the Krishna River Basin to improve water productivity in agriculture

Multilateral

Overseas Collaborating Countries	India
Commissioned Organisation	International Water Management Institute, Research - Hydrology and Water Resources, India
Collaborating Institutions	Dr Luna Bharati Phone: 94 11 2787 404 Email: l.bharati@cgiar.org
Project Budget	University of Melbourne, Department of Civil and Environmental Engineering, Australia Jawaharlal Nehru Technological University, Centre for Water Resources, India
Project Duration	$1,142,273
ACIAR Research Program Manager	01/07/2004 to 30/06/2008

Project background and objectives

India's Krishna River Basin covers an area in excess of 250,000 km², or around 8 per cent of India's land mass. The Basin is shared between three large central states, Karnataka, Maharashtra and Andhra Pradesh.

Demand for water, driven by population growth, is increasing, agriculture representing 95 per cent of this. Industrial (2 per cent) and domestic use (3 per cent) accounts for the rest. Water allocations in the basin have been based on the rulings or the 1969 Krishna Water Disputes Tribunal.

Since that time the basin's water use has focused on crop irrigation in the semi-arid central region, diverting water from the Krishna Delta 'Rice Bowl'. River flows to the ocean have ceased – a situation that mirrors what has occurred in Australia's Murray Darling Basin.

This similarity, along with questions of water consumption for agriculture as opposed to use for environmental flows, have been addressed in Australia.

The Indian Parliament has reconstituted the Krishna Basin Tribunal to negotiate the balance of flows and allocations for the next 4 to 5 years. The Tribunal's challenge is to provide the relevant information to ensure decisions that lead to sustainability and cater for the needs of a growing population while not exceeding levels of likely supply. Helping provide that information is the focus of the project.

Project Progress

Year 3 (01/07/2006–30/06/2007)

During the mid-term review held in Nov 2006 it was agreed that inter-sectoral water allocation modelling would focus on the three sub-basins: Musi, Malaprabha, and Upper Bhima from the three riparian state of the Krishna basin – namely Andhra Pradesh, Karnataka and Maharashtra respectively.

During the reporting period the work on the project centred on the following activities:

- groundwater modelling in Musi sub-basin to estimate ground water recharge
- the development and completion of a water allocation model for the Musi that includes a groundwater component
- the simulation of water allocation scenarios in the Musi sub-basin
- the development of an approach that can be applied to assess the economic components of various water allocation scenarios
- the completion of a Social Benefit Cost analysis of water allocations in the Musi sub-basin
- An assessment of the relative values of water in the Musi sub-basin
- Hydrological modelling for Malaprabha
- Setting up the Soil and Water Assessment Tool (SWAT) model for Upper Bhima.

Musi Sub-basin (Andhra Pradesh)

The Musi sub-basin represents a wide spectrum of water use and demand patterns: urban demand for domestic and industrial use in the greater Hyderabad City area. Agricultural demands include a medium-sized irrigation scheme in the middle of the basin and irrigated area in lower reaches as a part of major irrigation project, Nagarjuna Sagar, in the lower catchment and ground water irrigation in the entire sub-basin.

Groundwater overexploitation of the Musi sub-basin has been quantified using historical piezometric time-series analysis. Based on records for 1989–2005, it was found that 2.5 m of saturated depth has been depleted with a depletion rate of 0.18 m per year. A physical groundwater model, MODFLOW was used to estimate the groundwater recharge.

It was estimated that the average recharge during monsoon was 17% of the mean total annual rainfall (1180 mm³). The sustainable utilisable water resource was estimated at 1220 mm³. It was also found that the artificial recharge structures could enhance natural recharge by 11%, which warrants further investigation.

REALM was used to build the Musi water allocation model, and simulate the water supply system. The model now consists of 11 supply nodes and 14 demand centres.

A scenario analysis was used to investigate possible changes to water allocations in the Musi sub-basin. For each scenario, levels of assured supply were estimated for each demand centre. Results from this analysis indicate that competition for water is very high. It was found that transfers of water from agriculture to urban use may well grow over years and the irrigation allocation is going to worsen over time. In assessing the relative values of water in the Musi sub-basin, it was necessary to adapt an approach (Social Benefit Cost analysis) discussed earlier in the project into a model of the sub-basin.

The modelling results indicate that the average net values placed on water used for agricultural purposes ranged from Rs.24/m³ in the wastewater region to Rs.55/m³ in the region upstream from Hyderabad.

Malaprabha Sub-basin (Karnataka)

The Malaprabha sub-basin is located in a semiarid area of the Krishna basin. The Malaprabha Major Irrigation Project and several groundwater and lift irrigation schemes are located in the basin. The current drinking and industrial demand are not significant, but are expected to grow to 20% of total water available in coming years.

There is only one major reservoir, Malaprabha, which has a live storage of 866 Mm³; yet with a 75% dependable inflow of 608 Mm³, the reservoir fills to 763 Mm³. There is a provision to import 198 Mm³ of water to secure assured supply in the command and also to export 156 Mm³ from Ramthal lift irrigation scheme to the Middle Krishna sub-basin.

The SYMHYD model was set up for Malaprabha using reservoir inflow data. The simulation period was from 1993 to 2003 (however, as no data existed for 2002 it was excluded from the analysis). From the model, runoff was predicted to be 40% of rainfall and 60% went to either groundwater or evapotranspiration (ET). Based on district-wise groundwater statistics, the groundwater potential was estimated to be approximately 20% of the rainfall.

A REALM model is being set up for two supply nodes, the Malaprabha reservoir and groundwater. preliminary scenarios to be developed include assessing the effects of projected urban demand, the impacts of export and import into the basin.

Upper Bhima Sub-basin (Maharashtra)

The hydrology and degree of water resource development in the Upper Bhima sub-basin is a microcosm of the whole Krishna basin. There is a gross storage of approximately 8194 Mm3 in eight major and more than 30 medium reservoirs in the sub-basin. During 2004–05, out of total water available (8700 Mm^3), 1274 (15%) was diverted westward for hydropower generation from Tata Hydel Power projects. The water uses for non-irrigation and irrigation accounted for 25% (2207 Mm³) and 35% (3,022 Mm³) respectively of total water available, while 25% (2167 Mm³) resulted in excess runoff.

During the drought in 2002–04, the downstream projects suffered drastically when total water available reduced to half and dead storages were used to meet the drinking water needs without any supply for irrigation. There is a provision to import 2238 Mm³ from Upper Krishna sub-basin to augment water supply in waterwater-scarce regions.

Agricultural water use in the Upper Bhima sub-basin was assessed by integrating ET data derived from remote sensing techniques with a process based hydrological model, SWAT. The calibrated model was used to derive a monthly basin water balance for the irrigation year 2004–2005 and the agricultural water use was quantified. The ET in the sub-basin was estimated to be 38,172 Mm³ (835 mm).

Of the total evaporative depletion, 42% was estimated to be non-beneficial. Thus, different water uses for this non-beneficial use can be explored. The model will be recalibrated with finer land use resolution data and simultaneously REALM nodes will be established.

LWR/2006/045: Modelling minimum residue thresholds for soil conservation benefits in tropical, semi-arid cropping systems

Bilateral

Overseas Collaborating Countries	India, South Africa
Commissioned Organisation	Consultant, Australia
Project Leader	Dr Merv Probert Phone: 61 7 33252987 Email: penmerv@acenet.net.au or merv.probert@csiro.au
Project Budget	$20,000
Project Duration	01/06/2006 to 30/09/2006
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

Researchers face the challenge of developing new farming systems and soil management practices to increase productivity while reducing damage to soil and water resources. Conservation agriculture (CA), whereby farmers seek to increase yields and gain efficiencies in input use while maintaining long-term productivity of land and water resources, is a new concept. But the fundamental premise of CA, based around the practice of retaining all residues, is subject to debate in drier climates, especially the semi-arid tropics (SAT), where greater competition for forages and fodder leads to lower levels of residue retention.

The aim of this project was to assess the potential soil resource and productivity gains achievable by implementing varying levels of crop residue retention in SAT regions.

Project outcomes

Addressing the issues of crop residue retention experimentally would be costly and require considerable time. Instead the project used a modelling approach to establish the minimum residue thresholds that would allow farmers to balance their livestock needs against the maintenance of the soil resource. The model used for the study was the Australian-developed APSIM, which has been widely used to address water and nitrogen management issues in farming systems of SAT regions.

The researchers used the model to undertake four case studies: two were maize cropping systems on sandy soils in southern Africa; the other two were one maize and one wheat cropping system on a vertisol soil at Dalby in southeast Queensland.

In each case there was a combination of scenarios, with five levels of residue retention (0, 25, 50, 75, 100% retained) and four levels of fertility involving fertiliser inputs and initial soil organic carbon (SOC) content. Outputs obtained from the model included: crop production (grain and stover), components of the water balance, and changes in SOC.

Results were recorded in terms of the long-term averages of crop yields and water balance components. However it was shown that this approach masked the complexity of the response to residue management. Seasonal-to-season variation was substantial, and responses in crop growth could change from positive to negative.

After studying the outputs from the simulations the researchers reached the following conclusions:

- The effects of retention of maize or wheat residues on average long-term crop production were modest. The largest effects were found for the maize system at Dalby. Judged in terms of excess water, this was the driest site.

- The simulations show that residue management has implications for soil organic carbon. For soils with low initial SOC, the thresholds of residue retention needed were approximately 60% for adequately fertilised crops. For nitrogen-limited crops, even 100% residue retention failed to maintain SOC (except at the location with the lowest SOC content). Where initial SOC was increased by 50%, around 100% retention of residues was the threshold needed for the location with the lowest SOC. But there were inadequate residues to maintain these higher SOC contents for the other case studies.
- In the study of crop yields and components of the water balance, the premise of threshold levels of residue retention (or of residues) that determine whether beneficial effects are obtained from conservation agriculture was difficult to resolve. Variations in rainfall, and carryover effects of water and/or nitrogen, complicate the interpretation of responses. Positive effects will occur where residues reduce runoff and/or evaporation – so that the crop experiences an improved water supply (generally in years of low rainfall) – but only where nutritional status is adequate.
- The results from the simulations emphasise that the response of such systems is complex and show why these systems are not well suited to experimentation. It seems unlikely that carrying out ‘simple’ experiments investigating conservation cropping will lead to a clear understanding of the system.

7.3 Subprogram 3: Policy options for trade and market reform to underpin agribusiness development

Projects:

Active	
ADP/2000/004	International food safety regulation and processed food exports from developing countries: A comparative study of India and Thailand
ADP/2002/089	Agricultural trade liberalisation and domestic market reforms in Indian agriculture
ADP/2004/045	Exploring alternative futures for agricultural knowledge, science and technology (KST)
Concluded	
PLIA/2005/123	Trends in world agriculture to 2030, implication for developing countries
Pipeline	
ADP/2006/145	Impact of changing agricultural markets on small-farm participation and poverty: Cases from India, Vietnam, and Indonesia
PLIA/2006/135	Trends in world agriculture to 2030 in India, China and Indonesia

ADP/2000/004: International food safety regulation and processed food exports from developing countries: A comparative study of India and Thailand

Bilateral

Overseas Collaborating Countries	India, Thailand
Commissioned Organisation	Australian National University, Australia
Project Leader	Professor Prema-Chandra Athukorala Phone: 02 6125 8259 Fax: 02 6125 3700 Email: prema-chandra.athukorala@anu.edu.au http://rspas.anu.edu.au/economics/aciar/
Collaborating Institutions	Research Information Systems for the Non-aligned and Other Developing Countries, India University of Melbourne, Australia International Food Policy Research Institute, USA Thammasat University, Thailand
Project Budget	$621,895
Project Duration	01/01/2002 to 31/12/2007 (Project extended from 01/01/2006 to 31/12/2007)
ACIAR Research Program Manager	Dr Simon Hearn

Project background and objectives

India and Thailand, like a number of other agricultural resource rich developing nations, have experienced significant expansion of processed food exports. In recent years Thailand has exported over US$10 billion worth of processed food (4 per cent of GDP) and India over US$3 billion worth (2 per cent of GDP).

However, both India and Thailand, and other developing countries, have experienced significant problems in exporting processed food to lucrative markets in developed countries. These trade conflicts often relate to food safety standards and their inability to meet the WTO Sanitary and Phytosanitary (SPS) Agreement. For example in 1999–2000 there were 860 shipments of fishery, vegetables and fruit products from India placed in detention in the US and 684 cases of products from Thailand.

SPS issues have become a significant source of international trade friction and dispute. While the development of food processing export industries offers enormous potential for rural development and economic growth in developing countries, problems with meeting these standards are considered a major constraint to achieving this growth. There is a lack of adequate information on the problems that constrain firms' ability to meet international standards.

This study aims to examine the policy, institutional and technical problems faced by processed food exporters in developing countries in meeting SPS requirements, and to identify appropriate policy measures minimise their negative impacts on exports and enhance their capacity to meet SPS standards while recognising the legitimate concerns in importing countries about safety

Project Progress

Year 5 (01/06/2006–30/06//2007)

Annual report not yet submitted by the Commissioned Organisation.

ADP/2002/089: Agricultural trade liberalisation and domestic market reforms in Indian agriculture

Multilateral

Overseas Collaborating Countries	India
Commissioned Organisation	University of Melbourne, Department of Economics, Australia
Project Leader	Associate Professor Sisira Jayasuriya Phone: (03) 8344 3880 Fax: (03) 8344 6899 Email: s.jayasuriya@unimelb.edu.au
Collaborating Institutions	National Council of Applied Economic Research, India NSW Department of Primary Industries, Australia
Project Budget	$399,824
Project Duration	01/01/2005 to 30/06/2008 (Project extended from to 30/06/2008)
ACIAR Research Program Manager	Dr Simon Hearn

Project background and objectives

Economic growth in India has not delivered benefits across the population, particularly in agriculture. Instead the importance of agriculture has been diminished, including in its capacity to contribute to food security and rural poverty alleviation. In part extensive regulation, both through central and state governments has hampered agricultural growth.

Domestic regulation can have widespread implications, socially and economically. Interventions in commodity markets, such as through state trading enterprises limit competition. Social implications relating to market-access also impact widely, such as in limiting opportunities for poor farmers to venture into markets delivering price premiums. In the case of India the potential of poorly performing markets or limited access to impact on tens of millions of people is very high.

Regulation of domestic markets can also distort international trade, particularly where prices are not set by the market. Australia has substantial expertise and experience in implementing domestic market reforms, and in developing efficient agricultural commodity markets. The export focus of many of these markets also provides relevance for managing trade implications and ensuring compliance with various international trade agreements.

Social aspects of market reforms, together with trade implications and market deregulation for greater efficiency are under examination, to:

- determine through review the main institutional and regulatory interventions in selected agricultural sectors
- analyse marketing system constraints in selected agricultural sectors and their impacts on prices, production, income, consumption, trade and efficiency through in-depth case studies
- identify, evaluate and quantify the impact of domestic market and international trade policy reform options on agricultural prices, production, income, consumption, trade and efficiency
- develop and disseminate a set of policy recommendations for more efficient markets to key stakeholders.

Project Progress

Year 2 (01/01/2006–31/12/2006)

2006 was the second year of this Project. The project team met all its stated objectives except for holding the mid-term workshop in Melbourne sometime close to the middle of the year 2006. This would now be held in Melbourne in February 2007.

This delay was partly because we were able to hold a project-related workshop in New Delhi in February 2006 (and a project Advisory Committee meeting) using funds obtained by NCAER from Foreign and Commonwealth Office of the British High Commission in New Delhi. This was a very successful workshop, showcasing initial results before a large group of senior government officials, corporate sector representatives, academics and representatives from both Australian and British High Commissions, including both High Commissioners. The workshop elicited much discussion and very useful feedback.

These additional funds also enabled the project team to undertake a larger primary survey of the farmers and the agricultural markets than was originally envisaged; 675 farm households and 18 regulated marketing yards in 6 states covering 4 major crops (cotton, groundnut, paddy and pulses (tur)) were surveyed.

Partial equilibrium models of an importing and an exporting STE were developed to model government intervention in the marketing of rice in India through state trading enterprises (STEs). The research team came up with some initial estimates of the likely distortions arising from state trading in the Indian rice and wheat markets and highlight issues to be addressed in further developments of this project.

A version of the GTAP CGE model was used to analyse the impact of complete liberalisation trade barriers by the high-income countries through complete dismantling of the three pillars of agricultural trade barriers.

India and many other developing countries would reap welfare gains more from getting market access for exporting primary and processed agricultural goods to the high-income countries rather than from removal of domestic and export subsidies by the high-income countries. Further, India and other developing countries would also reap welfare gains when they dismantle their own import tariff barriers. However, there would be allocative effects on factors of production. An important result is that India would become relatively competitive in animal husbandry and meat products.

Econometric analysis was undertaken for the first time in India to study the impact of post-1990 reforms on market integration both across different states of India and between domestic and international markets in rice and wheat. (This work has now drawn Dr Jae Kim, Monash University, into the project research team.) Initial results indicate that reforms have enhanced integration with international markets. The research would be extended to further study price transmission in both rice and wheat markets, and to assess if integration is quicker and more complete in states which have implemented deeper policy reforms.

A related analysis evaluates the experience of existing Indian commodity markets to determine if, and to what extent, market instruments can substitute for state trading interventions and direct regulatory interventions to achieve price and farm income stability.

ADP/2004/045: Exploring alternative futures for agricultural knowledge, science and technology (KST)

Multilateral

Overseas Collaborating Countries	China, India
Commissioned Organisation	International Food Policy Research Institute, USA
Project Leader	Dr Mark W Rosegrant Phone: 1 202 8625621 Fax: 1 202 4674439 Email: m.rosegrant@cgiar.org
Collaborating Institutions	Australian Bureau for Agricultural and Resource Economics, Australia Center for Chinese Agricultural Policy, China World Bank, USA National Council of Applied Economic Research, India
Project Budget	$590,209
Project Duration	01/06/2005 to 30/06/2008
ACIAR Research Program Manager	Dr Simon Hearn

Project background and objectives

How agricultural knowledge, science and technology (KST) reach end-users, particularly farmers, remains poorly understood. While technologies have introduced a variety of improvements and science continues to deliver new knowledge, innovations likely to help many farmers, fishers and others have yet to reap benefits.

The gap between the developed and developing worlds can, in part, be narrowed through agricultural productivity improvements reaching poor farmers. In many developing countries, however, the means to increasing production has failed to reach poor farmers, with KST not delivered in a suitable format. An increasing level of uncertainty stemming from a variety of factors; changing socio-political environments, shifts in public and private investment, population and economic growth and avenues or pathways to adoption, mean future delivery of KST will need to be well understood.

Of these factors it is the last—avenues or pathways to adoption of KST—that this research seeks to illuminate. Alternative development pathways to agricultural KST adoption will be developed, catering to likely future trends. The implications of these on policy options and investment strategies, including economy-wide trade and subsidy policies, will be examined.

Descriptive narratives to support these scenarios will be used, along with modelling of these scenarios. This will be undertaken in close collaboration with the two year International Assessment of Agricultural Science and Technology for Development (IAASTD) initiative.

The project is providing policymakers with options of alternative policies and investments for agricultural knowledge, science and technology (KST) based on the analysis of alternative development paths and their implications for food security, rural development, and environmental sustainability.

Project Progress

Year 2 (01/06/2006–31/05/2007)

The project goal is to provide policymakers with options of alternative policies and investments for agricultural knowledge, science and technology (AKST) based on the analysis of alternative development paths and their implications for food security, rural development, and environmental sustainability.

The project is being implemented in close collaboration with the 2-year IAASTD initiative (www.agassessment.org). Outputs under Objectives 1 and 2 were achieved during the first reporting period (1 July 2005–1 July 2006), and Objective 3 and part of Objective 4 were partially achieved during this reporting period.

One change occurred in November 2006 that led to a change in outcomes of Objective 1. The Bureau of the IAASTD decided to replace the approach of four to five storylines with the development of a reference or baseline run combined with the analysis of a series of policy issues.

Activities under Objective 3 include the analysis of final model results, and the development of investment implications for alternative scenarios and KST implications. Outputs under this objective include a report on the analysis of model results, a report on final scenario outcomes, and implications for investment. Activities under Objective 4 include the analysis of implications of trade and subsidy policies within the scenarios, in particular, for food production and food security.

Feedback effects between the global CGE model (ABARE's GTEM model) and the global partial agricultural equilibrium model (IMPACT) were implemented, as were additional feedback loops between an Integrated Assessment model and IMPACT. This was a project activity lagging behind from the first reporting period. Moreover, a draft chapter with five storylines was submitted in August 2006.

A second draft was submitted in April of 2007 replacing the storyline approach with a reference world or business-as-usual approach, together with six quantitative and six qualitative policy issues. Quantitatively assessed policy issues include climate change policies and agriculture, trade policies and international market constraints, investment in AKST, bioenergy, water productivity, and changing preferences for meat and certified organic products; qualitative assessments included: Agricultural resource management and land tenure issues, food safety and food security, biotechnology and biodiversity, information and communication technologies and local knowledge, urbanisation and migration, and the interface of human, animal, and plant health.

Investment calculations have been implemented, but have not yet been submitted to IAASTD. Two alternative trade scenarios have been developed for IAASTD, but a separate report on trade and subsidy scenarios has yet to be developed, and has been slightly delayed. One of the most surprising outcomes of the chapter is that long-term trends of global food supply and demand indicate a tightening of world food markets, and that growing resource scarcity combined with continuing increases in demand for the first time in many years indicate long-term increasing food prices for major staple crops and meats.

Regarding outreach and dissemination (Objective 5), project researchers again attended several meetings during the reporting period:

- August 12–16, 2006, Gold Coast: IFPRI organized a Mini-symposium at the International Association of Agricultural Economists titled 'Millennium Ecosystem Assessment (MA) – Implications for the International Assessment of Agricultural Science and Technology for Development (IAASTD)' for Thursday, August 17
- November 6–10, 2006, San Jose, Costa Rica: Third Global Authors meeting to respond to comments of the first round of reviews and Bureau
- June 10–14, 2007, Cape Town, South Africa: Fourth Global Authors meeting to respond to comments of the second round of reviews and Bureau.

PLIA/2005/123: Trends in world agriculture to 2030, implication for developing countries

Bilateral

Overseas Collaborating Countries	China, India
Commissioned Organisation	Centre for International Economics, Australia
Project Leader	Dr Andrew Stoeckel Phone: (02) 6245 7800 Email: astoeckel@thecie.com.au
Project Budget	$30,000
Project Duration	01/11/2005 to 29/12/2006 (Project extended from 30/06/2006 to 29/12/2006)
ACIAR Research Program Manager	Dr Jeff Davis

Project background and objectives

China has become the 'OPEC of the world on the demand side' for commodities, and India looks set to take off and follow. Together, they have the potential to alter world agriculture markets greatly. Analysing these developments, and understanding the importance of these and other global drivers, is crucial for sound strategic planning in rural industries.

The overall objective of this research is to analyse the major drivers behind the trends in world agricultural production and consumption to 2030. This will be undertaken in two parts; firstly a scoping-study to define the project in light of other world research. This will involve workshops in China and India to crystallise the issues, identify other partnering institutions, and specify the drivers affecting world agricultural markets in 2030. Secondly, the information gathered will be disseminated through publications, seminars, meetings and conferences.

Project Outcomes

Agriculture is big business in the world. After all, every one of the six billion people on the planet eats food. Unfortunately there are millions of people with too little food, or of the wrong type. United Nations puts the number of under-nourished people at 815 million in 2002 (UN 2005, p8). As the world changes, so do the demands and supply of food. Rising populations and incomes change demands. Changing technology, land availability, water and other inputs like energy impact on the type and amount of food that can be grown. Environmental pressures are yet another factor affecting the future supply of food.

Matching demands and supplies of food is mostly left to markets and trade within and between countries, but there is extensive intervention by governments at every level of the supply chain in the production, distribution and consumption of food. With so many changes in population, incomes, technology and policy, major issue is what the outlook for agriculture is like over the next 20 to 30 years. The FAO projects food supplies and demands for the next 20 to 30 years on a regular basis. But these projections rely on many assumptions that do not necessarily hold true today. For example, the price of oil was assumed to be exogenous and to fall in the FAO's latest projections of world agriculture to 2030. And the rising population and incomes used in that study that were to 'drive' the demand for food were assumed not to affect the demand for oil. Yet we know that agriculture is more 'oil intensive' than most other sectors through its direct uses such as machinery and transport and indirect uses such as its use in making fertiliser.

This study is a review of the methodology used by the major institutions in the world projecting the outlook for agricultural products over the next two or three decades. The approaches taken and the main assumptions are examined along with a discussion of the possible consequences of treating some factors as exogenous. A more complete treatment (in other words, endogenising some of the critical factors treated as exogenous) is discussed along with the scope of such a study. This scope includes a discussion of a preferred framework and what a more complete treatment could involve by way of country and commodity coverage.

7.4 Other Projects

Projects:

Active	
AH/1997/058	Increasing the productivity of cattle in India and Australia with rumen fungal treatments
AH/2001/005	Salinity reduction in tannery effluents in India and Australia
FIS/2002/001	Developing aquaculture in degraded inland areas in India and Australia
FIS/2002/075	Application of PCR for improved shrimp health management in the Asian region
FIS/2006/144	Strengthening regional mechanisms to maximise benefits to small-holder shrimp farmer groups adopting better management practices (BMPs)
Concluded	
AH/1997/115	Increasing efficiency and productivity of ruminants in India and Australia by the use of protected nutrient technology

AH/1997/058: Increasing the productivity of cattle in India and Australia with rumen fungal treatments

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	CSIRO Livestock Industries, Long Pocket Laboratories, Australia
Project Leader	Dr Chris McSweeney Phone: 07 3214 2665 Fax: 07 3214 2203 Email: chris.mcsweeney@csiro.au
Collaborating Institutions	National Institute of Animal Nutrition and Physiology, India
Project Budget	$718,392
Project Duration	01/01/2003 to 30/06/2008 (Project extended from 01/12/2006 to 30/06/2008)
ACIAR Research Program Manager	Dr Peter Rolfe

Project background and objectives

Cattle are the most important providers of food (milk) from domesticated animals in India. Around 70 per cent of India's one billion plus population rely on agriculture with livestock husbandry usually carried out on smallholder farms. Cropping is usually also carried out, with crop residues used to feed cattle, along with other agricultural by-products.

Despite producing around 75 million tonnes (Dairy India 1997) annually demand cannot be met. Increasing the productivity of ruminants that produce milk will lessen the gap between demand and supply. Two options exist for achieving this increase; improving feeds or improving the ability of ruminants to utilise their dietary intake. The first option relies on increased grain production or diverting available grains from human to animal diets. Neither is a likely short-term possibility.

Treatments that help ruminants better digest and process the fibre component of dietary intake would improve milk production. Feed must first provide for the animal's energy and protein requirements. Without increasing feed quantity or quality the only other means of increasing the outputs from available feeds is to improve the efficiency of which animals extract nutrients during digestion. A flow-on effect of this would be improved milk production. Investigating the efficacy of such a treatment using fungal dosing to improve digestive extraction of nutrients will determine the applicability of this approach in India.

The overall aim of the project is to improve the nutritional status in the rural poor by increasing the availability of milk in the diet. This will be achieved by providing dietary treatments which encourage greater utilisation of crop residues for milk production by large ruminants in small holder units in India.

Project Progress

Year 4 (01/01/2006–31/12/2006)

Ruminant production is most important in the provision of food and clothing, both in the developing and the developed world particularly in India. Feed quality has been identified as one of the most important limiting factors responsible for low animal productivity in many of the developing countries in Asia, including India. Improvement in the nutrient utilisation of low quality roughages would substantially improve the ruminant productivity including milk production and efficiency of production.

This project attempted to improve the digestibility of the fibre component of the diet of ruminants so that milk production will keep pace with the growth of the human population. Two treatments were developed for improving the intake of poor-quality herbage by cattle. These treatments involved the use of a nutritional supplement to selectively enhance fibre degrading activity of anaerobic fungi in the rumen and a living fungal inoculant.

A variety of fungal-specific nutrients were examined both *in vitro* and *in vivo* for their effects on microbial populations in the rumen and production parameters. The organic S nutrients mercapto-1-propionic acid (MPA) and 3-mercapto-1-propanesulfonic acid (MPS) were tested in vivo in three different cattle experiments and compared to an inorganic S control. The effects on feed intake in the three experiments were variable and there was no effect on digestibility, but there was consistent improvement in nitrogen utilisation and microbial protein production.

The range of organic compounds that was evaluated does not appear to be fungal specific. Cellulolytic bacterial species also used these compounds as a sulfur source and the results from quantitative real time PCR analysis of rumen fluid indicated that there is a more general effect of these compounds on microbial populations in the rumen. The effects in cattle appear to be due to a general improvement in the efficiency of microbial fermentation of lignocellulose and not from specific stimulation of fungi. The benefits observed in animals supplemented with organic compounds were over and above inorganic S and the mechanism behind this improvement warrants further investigation.

One major cattle experiment was undertaken in India to examine the effect of the organic S supplement on milk production. Cattle were fed a standard diet used for dairy cattle in India and supplemented with MPS, inorganic S or given no supplement (control). The response in milk production, fat content and rumen fermentation parameters were measured after peak lactation. MPS improved milk production more than the inorganic supplement, which was also higher than the control. There was no difference in voluntary food intake but N metabolism and VFA were both improved significantly in the MPS treated animals. There appears to be a real effect on milk production that is most likely due to the improved patterns of rumen fermentation, lower rumen ammonia and increased VFA, but it needs to be examined in animals over an entire lactation. Because of these positive responses in milk production further experiments will be undertaken in India using cattle at the start of their lactation curve to get an accurate estimate of the size of the total response in milk production.

As part of developing a fungal inoculum for improving lignocellulose utilisation, 2000 faecal and rumen samples were taken from large and small, domestic and wild, ruminants in India and Australia. Approximately 200 fungal isolates were obtained from these samples and characterised morphologically and at the molecular level. All 5 genera normally found in the rumen were represented as well the genus *Cyllamyces*. This was only the second report of *Cyllamyces* being isolated from ruminants and the first in buffalo.

The NIANP has been nominated by ICAR as the site of a central fungal culture collection/database and expertise in India and arguably holds the most diverse ruminal fungal collection in the world. The fibre degrading capability of all of these isolates was determined and several elite strains were used as a fungal inoculum. Molecular-based methods for tracking fungi were developed by the Australian team, which were useful for describing fungal populations in the rumen

Different fungal inoculums containing elite fungal isolates were developed in Australia and India and tested in vivo in three different experiments with cattle fed low quality feed. The results from these experiments were inconsistent and this may be related to complementarity of fungal strains in the inoculum with those already present in the rumen.

What was clear from the work in both India and Australia was that this approach for improving productivity is not practical or cost effective at this time because of the time and effort involved in the process of isolating, characterising and culturing enough of the fungal cocktail for inoculation and the complicated nature (and our lack of understanding) of fungal ecology in the rumen.

AH/2001/005: Salinity reduction in tannery effluents in India and Australia

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	CSIRO Textile and Fibre Technology, Australia
Project Leader	Dr Catherine Money Phone: 03 98193406 Email: c.money@bigpond.net.au
Collaborating Institutions	Central Leather Research Institute, India Kreglinger Australia, Australia Black Diamond Industries, Australia
Project Budget	$816,090
Project Duration	01/07/2002 to 31/03/2008 (Project extended from 01/07/2005 to 31/03/2008)
ACIAR Research Program Manager	Dr Peter Rolfe

Project background and objectives

The leather industry is India's fourth largest export industry, employing 2.5 million people and having a target value of about $A10 billion in 2002. The preparation of leather requires the use of large amounts of salt. Tannery discharges are causing loss of agricultural production due to the salinisation of rivers and groundwater. It is also adding to the salinity of drinking water. In the past few years, Indian authorities have set stringent regulations for tannery discharges. Regulations for biochemical oxygen demand, chemical oxygen demand and chromium levels are now being met, though at considerable cost.

However, levels of total dissolved solids (TDS) remain too high. If the tanning industry does not deal with this problem, it will face legal action and closures, leading to social and economic hardship. The leather industry is also important in Australia, where it accounts for $A1 billion in exports each year. As in India, salinity is a major problem, and new licensing charges for effluent disposal are a major threat to some Australian tanners.

Salt cannot be eliminated from tannery processes, but previous studies have suggested that total dissolved solid levels can be reduced by using chemicals or chilling rather than salt for short-term preservation, by processing 'green' rather than salted hides, by using improved 'pickle' recycle techniques and by using better chrome liquor recycling methods.

The project is working to develop, evaluate and widely apply practical, viable systems to eliminate or reduce salt use in hide and skin preservation and processing, in order to significantly reduce the salinity of tannery effluent in India and elsewhere.

Project Progress

Year 5 (01/07/2006–30/06/2007)

In 2007 the salinity or TDS (Total Dissolved Solids) situation in Tamil Nadu (TN) remains critical for the tanning industry. Common Effluent Treatment Plants (CETPs) must meet 2100 ppm TDS or have zero effluent discharge which means installation of RO (Reverse Osmosis). Therefore all TN tanneries or their CETPs require RO. RO concentrates are to be solar evaporated.

Most tanneries in Erode have inadequate solar evaporation systems and improvement of the systems will be another major expense. No answer has been found for disposal or use of large amounts of the recovered evaporated salts. Other than for application to coconut palms in Kerala, no disposal options are available for these mixed salts; they will be piled at tanneries and it is likely that during the monsoon they will be dispersed into the environment.

In November 2006, three Erode tanneries were closed down on account of pollution problems. At present the main focus seems to be on zero discharge rather than TDS and salt use reduction measures, though both are intertwined. Eventually the Government and industry must realize this. Both approaches will necessary to achieve satisfactory environmental outcomes: low TDS in effluent and less waste salt.

The advantage of the four ACIAR Project developments is that salt use is reduced and the problem of recovered salt is greatly reduced. Cleaner processes are better than end-of-pipe treatments. The developments could make zero discharge from some tanneries feasible.

To achieve significant salt use reductions in India, there will need to be considerable uptake of low-salt preservation of skins and chilling of hides. The proposed low-salt preservation will entail little change for first handlers of skins but greater care will be required to ensure even salt application. There will be resistance to change. One possibility that may bring about change: the tanner could pay more for skins with less salt and good preservation and less for skins with excess salt.

The costs associated with chilling will be considerable. To achieve industry implementation, Government may need to provide funding and incentives to tanneries as have been available for RO installations. Progress in industry implementation for improved hide and skin preservation technology:

Low salt preservation

Studies have demonstrated hides can be preserved with only 20% salt by weight. This will reduce salt use 3- to 4-fold and there will be few salt crystals on the skins and little solid salt waste. An additive must be used with the salt to achieve good preservation. The additive used with the salt in industry trials up until July 2005 was magnesium oxide, but there have been problems with the flesh sides of the skins sticking together in summer. The tannery collaborating on the low salt system has achieved good results with skins preserved with 20% salt and 2% sodium carbonate. A larger trial with 750 skins has also given encouraging results.

Chilling

The main advantage of chilling is that salt is not used in preservation. For processing 1 tonne of hide, it is possible that 500 kg less salt is used and discharged and disposed of as solid waste. In India the system will need:

- blast chillers with generators and additional chilled storage areas at collection centres
- insulated trucks, in some cases with an air conditioner, for transport
- chilled storage areas for holding hides at tanneries before processing.

It is considered that the best way to achieve implementation of chilling is to have one system operating as a demonstration. KKSK Tannery in Erode is the best tannery to do this. After major recent capital expenditure, including installing RO and extended solar evaporation, KKSK is meeting TDS requirements and has achieved zero effluent discharge. Kerala coconut farmers take the recovered salts. Rafiq of KKSK considers that eventually all Erode tanners could use chilling. KKSK wants to implement chilling and to demonstrate the technology to the industry.

CLRI has applied for funding from Government agencies including the Central Pollution Control Board for the implementation of chilling.

Direct Chrome Liquor Recycling (DCLR)

To implement DCLR and demonstrate the technology to the industry, a plant is being installed at Abdul Azeez Tannery (SAA), Erode.

Pickle Liquor Recycle (PLR)

One Dindigul tannery which used to discharge pickle liquor after each use has successfully adopted the system for regular processing. The tanner is demonstrating the system to other tanners.

FIS/2002/001: Developing aquaculture in degraded inland areas in India and Australia

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	NSW Department of Primary Industries, Australia
Project Leader	Mr Stewart Fielder Phone: 02 49163902 Fax: 02 49821232 Email: stewart.fielder@fisheries.nsw.gov.au
Collaborating Institutions	Murray Irrigation Limited, Australia Central Institute of Fisheries Education, India Indian Council of Agricultural Research, India
Project Budget	$544,044
Project Duration	01/01/2004 to 31/12/2007 (Project extended from 31/12/2006 to 31/12/2007)
ACIAR Research Program Manager	Mr Barney Smith

Project background and objectives

Degraded agricultural land is a problem common to both India and Australia. Large-scale irrigated agriculture, practiced in semi-arid and arid areas can create water-logging and salinity. Rising groundwater tables, both of high quality (freshwater) and low quality (saline) contribute to and are causal factors in water-logging and salinity. In India approximately 8.7 million hectares of land is salt affected, in Australia 2.5 million hectares.

Management options severely constrict agricultural output on what is already marginal land. In Australia one management method is pumping rising saline groundwater out of shallow aquifers into large ponds, allowing evaporation to remove the water. These schemes are, however, expensive and non-productive for outputs. In India land ownership issues and cost have impeded the adoption of this approach.

The use of aquaculture in saline ponds offers a potential solution and incentive to utilise such schemes. Demand for seafood is rising worldwide, increasing pressures on fisheries. Many are in danger of being overfished, with declining catch levels. Long-term overfishing can also result in the collapse of fisheries. To alleviate these pressures aquaculture is being seen as a viable alternative, including as a potential means of delivering outputs and profitability in rehabilitating saline lands.

Developing and integrating sustainable aquaculture in degraded agricultural areas using low salinity groundwater from shallow aquifers relies on production strategies for growth and survival of salt-tolerant freshwater species and estuarine/marine species. Species have been selected for research and development based on sound technology already existing for culture of these species in 'natural' freshwater, estuarine or coastal environment and/or an existing industry for seedstock production.

Project Progress

Year 3 (01/01/2006–30/06/2007)

Annual report not yet submitted by the Commissioned Organisation.

FIS/2002/075: Application of PCR for improved shrimp health management in the Asian region

Bilateral

Overseas Collaborating Countries	India, Indonesia, Thailand
Commissioned Organisation	CSIRO Livestock Industries, Australian Animal Health Laboratory, Australia
Project Leader	Dr Peter Walker Phone: 03-5227 5165 Fax: 03-5227 5555 Email: peter.walker@csiro.au
Collaborating Institutions	Mahidol University, Thailand Directorate General Aquaculture, Indonesia Network of Aquaculture Centres in Asia Pacific, Thailand Agency for Marine and Fisheries Research, Indonesia
Project Budget	$715,920
Project Duration	01/01/2005 to 31/12/2007
ACIAR Research Program Manager	Mr Barney Smith

Project background and objectives

Shrimp farming, or culturing, is a profitable industry. Successful culturing provides income and employment for smallholder farmers, as well as those working in hatcheries, larger-scale farms, feed mills and processing plants. Most of this has flow-on effects as income is redistributed throughout the usually poor rural communities, many located in coastal regions that practice shrimp culturing.

In addition to these benefits farming of shrimp is sustainable. This relieves the pressure placed on wild populations being harvested at unsustainable catch levels, motivated by reaping the potential income on offer. Thailand leads the world in farmed shrimp production, with Indonesia and India, like many other countries in Asia, both major and growing producers.

For the past decade the Asian industry has been limited by disease outbreaks. Several have been serious enough to cause declines that if continued unabated would threaten the industry. Two diseases in particular, white spot syndrome virus (WSSV) causing white spot disease and yellow head virus (YHV) have caused these declines. Past ACIAR research has developed polymerase chain reaction (PCR) and epidemiological tests to identify the diseases. These are used to detect the viruses in seed stock and live shrimp respectively.

Despite these being widely adopted outbreaks continue, and a slow growth syndrome has become more prevalent, prompting further research into PCR use and its role in ongoing farm management.

The project will focus on:

- reducing the risk of White sport disease in shrimp farms through the application of PCR-based detection tests and epidemiological probes;
- reducing the risk of yellow head and other shrimp diseases in shrimp farms through application of PCR-based detection tests and epidemiological probes; and
- improving the effectiveness of PCR-based viral screening in hatcheries and service laboratories in India, Indonesia and other countries in the Asian region.

Project Progress

Year 2 (01/01/2006–31/12/2006)

This project aims to reduce risks of disease outbreaks in small-holder shrimp farms by a combination of strategies involving training of PCR laboratory technicians, the inter-calibration of PCR laboratories test performance and improved health management practices derived from a better understanding of sources of white spot disease on farms. A major aspect of the project is a large field study at a site in Andhra Pradesh, India.

The study is the first in a series of investigations that aim to assess the quality of PCR screening available to small holder shrimp farmers and to identify the sources of disease outbreaks in shrimp ponds.

The study involved a total of 457 ponds from 28 clusters in 15 villages. The farms were stocked in early 2005 with PCR-screened PLs obtained from local hatcheries. Samples of shrimp post-larvae (PLs) were collected from farmers at the time of stocking and from juvenile shrimp and wild crustaceans from the ponds during grow-out and at the time of disease outbreaks and planned or emergency harvest.

Samples collected from the site were tested by laboratory staff in India and Australia by PCR to identify infected stock and assess the source of infection. Samples from disease outbreaks were also examined by histology to determine the cause of disease. The results indicate that very few of the PL batches used by the farmers in the study were positive by PCR tests conducted in India and Australia by the project team, suggesting that PCR screening conducted by local laboratories was relatively effective.

However, PCR testing of samples collected from shrimp at planned or emergency harvest indicated there was a very high prevalence of WSSV infection in the study ponds with a high proportion of moderate-severe infections. There was also evidence that a small number of nursery ponds were the source of seed for a high proportion of disease outbreaks during grow-out. There was also evidence of clustering according to the village under study with two villages in particular being major foci of infection and disease. The data suggests that nursery ponds may be a weak link in the current disease management practice.

Work has also continued in the search for infectious agent associated with monodon slow growth syndrome (MSGS), a newly emerging disease that has impacted severely on *P. monodon* production in Thailand. At Centex Shrimp in Bangkok, a new shrimp virus (Laem Singh virus — LSNV) has been investigated. Although LSNV occurs commonly in *P. monodon* in Thailand, it is thought that progression of the infection in the optic nerve may be the cause of slow growth.

To determine if LSNV also occurs in India, 205 samples collected in the field study in Andhra Pradesh were screened for the presence of the virus using PCR test developed at Centex Shrimp. Although no evidence of infection was detected, we have concerns about the stability of the LSNV RNA after prolonged storage in ethanol and new set of samples will be collected in early 2007.

To improve the reliability of PCR-based screening, the first of two inter-laboratory calibrations of WSSV PCR testing was conducted in India in June 2006. Forty-nine service laboratories from the government and private sectors and shrimp hatcheries received equivalent sets of randomly coded positive and negative samples comprising fixed shrimp tissues WSSV DNA for testing. Seventeen laboratories correctly identified all positive and negative samples and three laboratories failed to detect only one low positive sample. Six laboratories reported negative results for positive samples indicating problems with test sensitivity. Nine laboratories reported positive results for negative samples indicating problems with test contamination. Two laboratories reported incorrect results for both positive and negative samples.

The results were collated returned to all participating laboratories in a form that allowed them to see the results of all laboratories but identify only themselves by code. A second inter-calibration is planned following the second PCR training workshop in early 2007 and it is expected that a national PCR laboratory accreditation program will commence in 2008. A similar inter-calibration commenced in Indonesia in December 2006.

The second in a series of two PCR training workshops has been completed in India. The second workshop was conducted in October 2006 for essentially the same group that attended the first workshop in 2005 including 23 from hatcheries and government, private and research laboratories in India and three participants from Sri Lanka, Bangladesh and Myanmar. The second workshop provided more focused training and assessment with each participant required to perform every step in the process at least once during the 4-day program and feedback was given on the basis of individual rather than group performance.

FIS/2006/144: Strengthening regional mechanisms to maximise benefits to small-holder shrimp farmer groups adopting better management practices (BMPs)

Bilateral

Overseas Collaborating Countries	India, Indonesia, Thailand, Vietnam
Commissioned Organisation	Network of Aquaculture Centres in Asia Pacific, Thailand
Project Leader	Dr C V Mohan Phone: 66 2 5611728 ext 115 Fax: 66 2 5611727 Email: mohan@enaca.org
Collaborating Institutions	University of Sydney, Australia Directorate General Aquaculture, Indonesia Department of Fisheries, Thailand Marine Products Export Development Authority, India Central Institute for Brackishwater Aquaculture, India National Fisheries Quality Assurance and Veterinary Directorate, Vietnam
Project Budget	$77,190
Project Duration	01/06/2007 to 30/11/2009
ACIAR Research Program Manager	Mr Barney Smith

Project background and objectives

Better Management Practices (BMPs) in the aquaculture context outline norms for responsible farming of aquatic animals. In aquaculture, better management practices have been developed largely for shrimp and salmon aquaculture, although some efforts are presently being made to develop them for other aquatic commodities (e.g. tilapias, catfish, molluscs, eels).

This project is building on the ongoing shrimp BMP programs in the Asia-Pacific region (e.g. in Australia, Indonesia, India, Vietnam and Thailand). It seeks to create a robust regional mechanism for networking and exchange of information, specifically focused to benefit small-scale shrimp farmers in Asia – to reduce disease risks, improve yields, produce quality shrimp, access better markets, address socio-economic sustainability and comply with international principles.

Project Progress

First progress report due in 2008.

AH/1997/115: Increasing efficiency and productivity of ruminants in India and Australia by the use of protected nutrient technology

Bilateral

Overseas Collaborating Countries	India
Commissioned Organisation	University of Sydney, Australia
Project Leader	Dr Suresh Gulati Phone: 04 1919 4986 Fax: 61 2 9804 0042 Email: sureshg@vetsci.usyd.edu.au
Collaborating Institutions	National Dairy Development Board, India
Project Budget	$821,152
Project Duration	01/01/2000 to 31/12/2006 (Project extended from 01/07/2005 to 31/12/2006)
ACIAR Research Program Manager	Dr Peter Rolfe

Project background and objectives

In India, milk-producing ruminants are kept not just for milk but as a source of fuel, fertiliser, draught power and income. Many people are vegetarian, so milk provides a valuable source of animal protein and it is widely consumed by all sectors of society. Unfortunately the Indian dairy herd, although very large, is among the world's least productive. Milk production per animal averages 3–5 litres per day, only about 10 per cent of that achieved in Australia. Reproduction rates are also low.

This poor performance is not just due to the Hindu reverence for cows, which means that old and unproductive cattle are not culled. There is also another problem—which applies to northern Australia as well—and that is the low nutritive value of much of the feed. In both areas, it is hard for the animals to digest and extract nutrients from the main pasture plants.

Considerable benefit could be achieved by providing animals in these circumstances with added nutrients—especially protein (of balanced composition) and lipids. However, actual absorption of nutrients given as a supplement is likely to be low because of the effect of the microbes in the rumen. Australian scientists have devised a way of protecting added nutrients in their passage through the rumen so that they are able to be digested further along the gut. This is termed protective nutrient technology. The nutrient supplements should be readily producible from easily available agricultural by-products.

The project aimed to establish and test the protective technology in Indian conditions, to convert readily available agricultural by-products into useful feeds that would survive passage through the rumen and thereby improve ruminant nutrition.

Project outcomes

In trials undertaken in cows/buffaloes in the state of Gujarat (Western region), feeding 1 kg per day of by-pass protein supplements manufactured at the National Dairy Development Board (NDDB) in Anand, India, compared to 1 kg of untreated meal, increased milk yield, fat and protein content with a net benefit to village dairy farmers of 8 to 12 rupees per animal per day. Similar results were obtained in the Karnal (Northern) and Orissa (Eastern) and a smaller increase was observed in Kerala (Southern) region of India.

NDDB was home to a pilot plant (designed and constructed in Australia and commissioned in April 2001) that produced up to 150 kg per batch of by-pass protein meal. This plant produced rumen-by-pass proteins with 75% rumen un-degradable protein (RUP) from Indian indigenous by-products, i.e. sunflower meal, guar-bhardo and rapeseed meal, for the evaluation and feeding trials. The positive economic benefits of these trials led to the design, construction and operation of a commercial plant at Itola, Vadodara, capable of producing up to 50 tonnes per day of a by-pass protein feed supplement.

A socio-economic analysis of village dairy farmers who fed by-pass protein supplements indicated that the benefits and economic impacts at the village level were greatest for farmers milking buffaloes, followed by local cows and crossbred cows, with a net income increase of Rs12.41, Rs9.26 and Rs7.28 respectively per animal per day. Disposable income of village farmers increased significantly and this could improve living standards and provide greater purchasing power for women, who manage the day-to-day village dairy farms.

The positive economic returns from feeding by-pass protein led to the construction of a second commercial plant in Godhra in Gujarat state in December 2005. This plant is producing up to 50 tonnes of by-pass feed per day and is providing supplements for cows/buffaloes owned by tribal and marginalised small village farmers in this region of India.

An additional output has been the development of a slow-release ammonia source, which when used in combination with by-pass protein feed supplements lifts milk production a further 5-10 per cent. This new development is being incorporated into the current manufacturing plant(s) and will also be a feature of future plants (under consideration for the states of Punjab, Rajasthan, Orissa and Kerala). At a national workshop conducted at the NDDB in November 2003 a key recommendation was to develop a ration-balancing system suitable for village dairy farmers. NDDB developed the system, and it is now producing positive responses.

NDDB staff members have trained in Australia and India, learning to produce by-pass protein and lipid supplements, also techniques for quality control, nutritional evaluation, and occupational health and safety requirements. The methods developed at Sydney University/CSIRO to measure the rumen un-degraded and rumen degraded protein (RDP/RUP) content of proteinaceous feedstuffs have been adapted by NDDB and found superior and more accurate to the standard phosphate buffer procedure currently used. Plans are under way to adopt these methods as part of the National Feeding Standards for India. All methods used during the project have been described in a manual entitled: Methods of analysis of protected nutrient supplements for ruminants (published by ACIAR).

The NDDB has established an experimental unit to produce by-pass fat supplements derived from oilseeds/oils/meals. It is now producing small quantities of by-pass fats to evaluate their role and potential economic applications in India. As a result of the project NDDB now has a well equipped functional laboratory and highly trained staff in preparation for future R&D programs in feed technology, ruminant nutrition and analytical service.

PART 2: PAKISTAN

8 Annual Report 2006-07

Active projects in 2006-07	9
AOP budgeted expenditure in 2006-07	$2,007,239
Actual expenditure in 2006-07	$1,658,786
Expenditure in 2005-06	$1,045,668
Expenditure in 2004-05	$506,033

Key performance indicators	Performance 2006-07
Agriculture Sector Linkages Program (ASLP) components implemented that address Pakistan priorities and make optimal use of Australian technical expertise	Three projects in mango production, mango supply chain development and citrus production have been implemented. A fourth project on increasing dairy extension effectiveness is due to be implemented in July.
Government of Pakistan (GoP) funded program to disseminate bed-planting technology in other maize-wheat growing regions initiated	A five-year, $11-million GoP program established aimed at establishing 1000 farmer cluster groups based on the model trialled and using technology developed by ACIAR.
Proof-of-concept of serial biological concentration of irrigation drainage water providing the basis for piloting in other districts of Punjab and Sindh provinces	While two pilot sites were successfully established, the original serial biological concentration concept did not work as well as anticipated.
Forty per cent of new projects designed to have farmer or policy impacts within five years of completion	The supply chain development project is specifically designed to achieve early impacts. Projects on mango and citrus production, are classified as medium term impact projects, but have elements that lend themselves to rapid dissemination and uptake by farmers.

8.1 Position

Pakistan has been an ACIAR partner country since 1984. In Pakistan, there is increasing pressure on availability of water resources for irrigation due to competing demands from urban and industrial uses. Soil and water salinity and drainage problems are placing additional pressure on irrigated agriculture. Given the similarity of some of Australia's water resource and salinity issues, Australia is very well placed technically to assist Pakistan in addressing the above issues. As a result, ACIAR's program continues to focus on irrigation, drainage and salinity management in the major cropping systems. Some of the technologies developed comprise the introduction of salt tolerant forage species from Australia to Pakistan and the use of Eucalypts to assist in drainage of shallow water tables.

In addition, there is recognition that Australia also has skills in some of Pakistan's key horticultural crops, mainly citrus and mangoes, the two most important tree crops. Australia can provide expertise in a 'whole of systems' approach to increase the productivity and competitiveness of the mango and citrus industries, encompassing fruit to market strategies.

Pakistan is also one of the world's largest milk producers, slightly less than half of which is produced from dairy cattle. Unit animal production is very low, although genetic potential is quite good. Major opportunities exist for applying Australian expertise in animal nutrition and the integration of forage production into farming systems to assist in improving milk production, a key to poverty reduction particularly for some of Pakistan's landless.

8.2 Achievements

Under the auspices of the **Agriculture Sector Linkages Program (ASLP)**, the Pakistan program is focusing on two thematic priorities: horticulture and dairy. Water is also a cross-cutting theme, which underpins these priorities as well as linking the expanded Pakistan program to earlier ACIAR-funded research. The focus of the past year has been to complete the design of four R&D projects. New projects were developed for the mango and citrus sectors and in the dairy production sector. A dairy knowledge fair was jointly organised with Austrade in Lahore in February 2007.

The sustainable development of the mango industry in both Pakistan and Australia has been hampered by **a shortage of high-quality fruit** for export. In addition to postharvest handling and storage, disease and pest losses, variable productivity due to orchard management issues, and market access challenges constrain mango industry development. A project seeks to establish 'clean' mango nurseries so that high-quality planting material is made widely available to the Pakistan industry. The project is also developing improved tree husbandry and management options to produce sustainable yields and quality fruit; to develop improved detection and management strategies for mango sudden death disease syndrome (MSDS) and other major diseases of mangoes, and to build research capacity in the mango industry.

Much of Pakistan's fruit and vegetable production, including mangoes, is not fully utilised—due to poor harvesting, handling and other postharvest practices. A project is addressing key constraints currently limiting the **efficiency, effectiveness and competitiveness of supply chains** for Pakistan mangoes. It aims to improve and maintain mango quality from harvest to consumption by identifying present market needs and likely future opportunities for Pakistan mangoes, through analysis of existing supply chains and the development of improved supply chain management systems and practices.

Pakistan has set an **annual export target for citrus** of 500,000 tonnes within the next 5 years, and $300 million in export earnings by 2013, but some key constraints need to be addressed to achieve these ambitious targets. A new project has been developed after an ACIAR-supported scoping study outlined key constraints to a more productive citrus industry. Its principal aim is to improve mandarin and orange productivity in Pakistan (and Australia) through improved nursery production practices, demonstration of 'best practice' orchard management, and enhanced research, extension and production capacity of Pakistan citrus institutions and industry.

Severe epidemics of **plant diseases caused by geminiviruses** have emerged in recent years. Australia and Pakistan have collaborated to learn more about them and particularly their effect on cotton and tomato crops. The upsurge in the occurrence of geminiviruses is linked to the spread of their vector, the whitefly *Bemisia tabaci*. Epidemics in Pakistan during the 1990s were especially severe, with huge losses in cotton and related industries, while in northern Australia the prospect of large losses through geminivirus of tomato is increasing. From field surveys and complementary work on virus characterisation the scientists have found that cotton leaf curl disease (CLCuD) in Pakistan can actually be caused by several different viruses. Virus disease complexes were also identified from leaf curl diseases of tomato, chilli, cucurbits, okra, papaya and the yellow vein disease of the weed *Ageratum conyzoides* (which acts a reservoir of infection for cotton crops).

In parallel with the cotton work, understanding of the tomato leaf curl disease and spread has been enhanced in Pakistan, AVRDC (The World Vegetable Centre) and Australia. The outcomes of this project will be used in plant breeding programs aimed at producing geminivirus-resistant cultivars of cotton and tomatoes.

Residue burning is widespread in rice-wheat systems of Pakistan, causing serious air pollution and loss of nutrients. In response to this problem, the Farm Machinery Institute (FMI) of Pakistan Agricultural Research Council (PARC) Islamabad recently designed and built a prototype machine (the 'FMI Seeder') for **direct seeding wheat into rice residues**, in a single operation based on a similar machine developed in another ACIAR project in the Punjab. However, while the problem has almost been solved mechanically, there are a number of agronomic issues to be resolved to achieve good establishment and crop performance.

A project is evaluating and refining the technology for a range of stubble, soil and seasonal conditions, and developing guidelines for achieving good establishment, efficient use of nitrogen fertiliser and high yields in rice–wheat and alternative systems. The project is making progress in further developing the machinery and establishing operational guidelines for the novel seeder, in preparation for its commercialisation and widespread distribution.

9 Annual Operational Plan 2007-08

GNI per capita ($US)	690
Population	154.8 million
Population 2015/2050	193.4/304.7 million
Active bilateral projects	7
Active multilateral projects	1

Bilateral actual 2005–06	$ 1.05 m
Bilateral estimate 2006–07*	$ 2.01 m
Bilateral budget 2007–08*	$ 1.99 m
Bilateral + multilateral budget 2007–08	$ 2.04 m

***Includes AusAID–funded projects of $1.53 m (forecast 2006–07) and $1.48 m (forecast 2007–08)**

9.1 Key performance indicators (2007–08)

- Mango supply chains mapped and opportunities to improve value generation identified for selected domestic and export markets
- Significant exposure of Pakistan researchers and extensionists to modern methods of knowledge transfer and agricultural extension in dairy production
- Bed planting and residue management systems using locally manufactured machinery achieving significant savings in irrigation water
- At least 40 % of new projects designed to have components leading to significant farmer or policy impacts within five years of completion

9.2 Medium-term strategy

ACIAR has broadened the program of bilateral and multilateral projects in Pakistan to encompass the horticulture and dairy sectors. These build on a longer-term focus on natural resource management issues such as efficient water use, salinity and drainage, and tillage options for irrigated cereal cropping. The broadened focus arises from the Australia–Pakistan Agriculture Sector Linkages Program (ASLP), which ACIAR is implementing on behalf of AusAID.

9.3 The Australia-Pakistan Agriculture Sector Linkages Program (ASLP)

The main goals of the agriculture linkages component are:

- to transfer Australian knowledge and expertise to key sectors of Pakistan agribusiness to increase profitability and enhance export potential
- to contribute to poverty alleviation of smallholder farmers through collaborative research and development
- to enhance the capacity of the Pakistan research, development and extension system to deliver targeted and practical research outputs to agribusiness and farmers.

It has been agreed to target the following priorities for technical support:

- increasing mango and citrus production, through diagnosis and control of diseases and orchard management to increase productivity and reduce input costs
- enhancing the supply chain, including value-adding and marketing for the mango and citrus industries
- increasing milk production from individual animals in the dairy sector.

To meet the ASLP goals and to ensure the program delivers early impacts, the program will be configured into a flexible suite of short-, medium- and long-term activities, comprising:

- initial short-term scoping studies and constraints analysis
- information exchange and exposure to agro-enterprises through visits to Australia
- technical and scientific workshops
- tailored training and capacity building packages delivered in Pakistan and in Australia
- technical intervention and research and development projects

The main anticipated outcome of the ASLP is to build stronger capacity in Pakistan to exploit agribusiness opportunities in the targeted sectors, with the dual purpose of underpinning the current high growth rates in the agricultural sector, as well as contributing to poverty reduction.

9.4 Position

Pakistan has been an ACIAR partner country since 1984. In Pakistan, there is increasing pressure on availability of water resources for irrigation due to competing demands from urban and industrial uses. Soil and water salinity and drainage problems are placing additional pressure on irrigated agriculture. Given the similarity of some of Australia's water resource and salinity issues, Australia is very well placed technically to assist Pakistan in addressing the above issues.

As a result, ACIAR's program continues to focus on irrigation, drainage and salinity management in the major cropping systems. Examples of the technologies developed are the introduction of Australian salt-tolerant forage species into Pakistan and the use of eucalypts to assist in the drainage of shallow water tables.

In addition, there is recognition that Australia also has skills in some of Pakistan's key horticultural crops: mainly citrus and mangoes, the two most important tree crops. Australia can provide expertise in a whole-of-systems approach to increase the productivity and competitiveness of the mango and citrus industries, encompassing fruit to market strategies.

Pakistan is also one of the world's largest milk producers, slightly less than half of which is produced from dairy cattle. Unit animal production is very low, although genetic potential is quite good. Major opportunities exist for applying Australian expertise in animal nutrition and integrating forage production into farming systems to assist in improving milk production. This work is viewed as a key to poverty reduction, particularly for some of Pakistan's landless.

9.5 Relationship to the AusAID South Asia strategy

The AusAID framework for assistance in South Asia over 2003–07 'seeks to maximise the effectiveness of programs reducing vulnerability and increasing the productivity of the poor' with an emphasis on the areas of 'health and sanitation, education and natural resource management'. It recognises that countries 'are at different stages of development, each with their own development priorities'.

The ACIAR program, while emphasising the agricultural sector, has a strong emphasis on reducing vulnerability and increasing productivity of the poor. The Pakistan program also addresses increased productivity in selected agricultural sectors as well as management of the natural resource base.

9.6 Indicative priorities

The most recent formal consultations were held in 2005 under the auspices of the Agriculture Sector Linkages Program (ASLP). Two new thematic priorities—horticulture and dairy—emerged from these consultations. Water was also identified as a cross-cutting theme that underpins these new thematic priorities and links the expanded Pakistan program to the past ACIAR focus. Consequently a broader focus on land and water resources, encompassing community-driven water allocation and drainage management as well as irrigated cereal production, will be retained through ACIAR's core program, complementing the ASLP.

In 2007–08 new projects will be considered to underpin irrigation management in the mango and citrus sectors. All new projects in Pakistan will include significant components of capacity building in participatory research and extension methodologies. Indicative priorities are grouped under the following themes:

Subprogram 1: Developing more productive and competitive mango and citrus production and marketing systems

- Diagnosis and control of diseases, especially dieback
- Orchard management to increase productivity and reduce input costs
- Optimising supply chains to increase value-adding and marketing opportunities
- Supporting linkages between farmers and the private agribusiness sector
- Policy analysis underpinning development of the horticultural sector

Subprogram 2: Improving livelihoods of dairy farmers

- Increasing unit animal productivity of dairy cattle though improved nutrition
- Supporting linkages between farmers and the private agribusiness sector
- Policy analysis underpinning development of the dairy sector

Subprogram 3: Management of land and water resources to sustain productive enterprises

- Strategies to optimise the value of limited and variable-quality irrigation water
- Technologies to improve productivity of saline land and water resources
- Resource-conserving technologies for irrigated horticultural and cereal-based farming systems

10 Projects (summary and progress reports)

10.1 Subprogram 1: Developing more productive and competitive mango and citrus production and marketing systems

Projects:

Active	
HORT/2005/153	Development of integrated crop management practices to increase sustainable yield and quality of mangoes in Pakistan and Australia
HORT/2005/157	Optimising mango supply chains for more profitable horticultural agri-enterprises in Pakistan and Australia
HORT/2005/160	Increasing citrus production in Pakistan and Australia through improved orchard management techniques
Concluded	
HORT/2005/154	Assessment of mango diseases, pest and production problems in Pakistan
Pipeline	
LWR/2007/008	Improved irrigation and salinity management to minimise water logging and optimise productivity in mangos and citrus in Pakistan and Australia
PLIA/2006/152	Adoption of technologies in horticulture and policy implications - Case study for citrus

HORT/2005/153: Development of integrated crop management practices to increase sustainable yield and quality of mangoes in Pakistan and Australia

Bilateral

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	Queensland Department of Primary Industries and Fisheries, Australia
Project Leader	Dr Chrys Akem Phone: 07 47830411 Fax: 07 47833193 Email: chrys.akem@dpi.qld.gov.au
Collaborating Institutions	Ayub Agricultural Research Institute, Pakistan National Integrated Pest Management Programme, Pakistan Agriculture Research Sindh, Pakistan Institute of Plant and Environmental Protection, Pakistan International Center for Agriculture Research in the Dry Areas, Pakistan
Project Budget	$1,049,928
Project Duration	01/01/2007 to 31/12/2009
ACIAR Research Program Manager	Mr Les Baxter

Project background and objectives

Significant scope exists for the further development of the mango industries in both Pakistan and Australia. In Pakistan the Government is seeking to quadruple horticulture sector export, including mangoes – from the current value of US$119 million to US$600 million within the next 5 years. The sustainable development of the mango industry in both countries is hampered by a shortage of high-quality fruit for export. In addition to postharvest handling and storage, disease and pest losses, variable productivity due to orchard management issues, and market access challenges are constraining mango industry development.

In Pakistan, the sudden death disease syndrome (MSDS) is an immediate production challenge facing the mango industry. Malformation and fruit flies are also widespread problems. In some cases the causal organisms of these diseases and pests have been identified, while for others these have yet to be confirmed. The availability of disease-free planting material and better tree management in conjunction with fertilisation and irrigation regimes that are better attuned with the mango growth cycle are seen as critical components of improved orchard management.

In Australia dendritic spot, a sporadic and unpredictable postharvest disease of mangoes which often occurs after postharvest treatments has been identified by over 60% of Australian growers as a constraint limiting the quality of marketable fruit.

The overall aim of the project, conducted under the auspices of the Australia/Pakistan Sector Linkages Program (ASLP) is to improve sustainable yields of quality mangoes in Pakistan and Australia, by establishing disease-free nurseries, developing integrated orchard and disease management approaches and building up capacity to deliver on-farm research and extension activities.

Project Progress

First progress report due in 2008.

HORT/2005/157: Optimising mango supply chains for more profitable horticultural agri-enterprises in Pakistan and Australia

Bilateral

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	University of Queensland, School of Natural and Rural Systems Management, Australia
Project Leader	Associate Professor Ray Collins Phone: (07) 5460 1328 Fax: (07) 5460 1324 Email: ray.collins@uq.edu.au
Collaborating Institutions	Department of Agriculture and Food, Western Australia, Australia Pakistan Horticulture Development and Export Board, Pakistan Queensland Department of Primary Industries and Fisheries, Australia University of Agriculture Faisalabad, Pakistan
Project Budget	$1,221,023
Project Duration	01/12/2006 to 30/11/2009
ACIAR Research Program Manager	Mr Les Baxter

Project background and objectives

Much of Pakistan's fruit and vegetable production, including mangoes, is not fully utilised — due to poor harvesting, handling and other postharvest practices. There are major constraints and inefficiencies in the Pakistan mango industry. After meeting domestic market requirements, a major part of the surplus crop is wasted. The mango is a highly perishable product, and product deterioration and market access problems are compounded by lack of infrastructure, storage and processing facilities, combined with poor market intelligence and communication — problems that also hamper market growth and efficiency in countries such as China, Vietnam and the Philippines. There is little evidence that government intervention in production, postharvest, distribution or marketing systems in any of these countries has resolved the problems.

One reason is that intervention strategies typically address parts of the supply chain rather than the whole supply chain as a complex, dynamic system. As a result, technical improvements to some parts of the supply chain have little impact on the economic well-being of producers. Supply chain participants who can command essential information use it to their benefit at the expense of other chain members, and retailers and consumers are unable to signal their needs to the parts of the chain where those needs can be addressed.

Faced with these circumstances, whole industries are unable to establish a reputation as a source of reliable, good quality, safe, value-for-money fresh produce - particularly on export markets.

This project, conducted under the auspices of the Australia/Pakistan Sector Linkages Program (ASLP), will address key constraints currently limiting the efficiency, effectiveness and competitiveness of supply chains for Pakistan mangoes. It aims to improve and maintain mango quality from harvest to consumption by identifying present market needs and likely future opportunities for Pakistan mangoes, through analysis of existing supply chains and the development of improved supply chain management systems and practices.

Project Progress

First progress report due in 2007.

HORT/2005/160: Increasing citrus production in Pakistan and Australia through improved orchard management techniques

Bilateral

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	NSW Department of Primary Industries, Australia
Project Leader	Dr Tahir Khurshid Phone: 03 50198433 Fax: 03 50274319 Email: tahir.khurshid@dpi.nsw.gov.au
Collaborating Institutions	Institute of Plant and Environmental Protection, Pakistan Orange Research Institute, Pakistan Horticulture Research Institute, Pakistan Agricultural Research Institute, Pakistan CABI South Asia Regional Centre, Pakistan International Center for Agriculture Research in the Dry Areas, Pakistan University of Agriculture, Faisalabad, Pakistan
Project Budget	$651,343
Project Duration	01/04/2007 to 31/03/2010
ACIAR Research Program Manager	Mr Les Baxter

Project background and objectives

Citrus is one of the major fruit crops of Pakistan. The country is currently an important global producer and, increasingly, an exporter. But most citrus production relies on one mandarin cultivar, Kinnow, and 95% of this crop comes out of Punjab province. Kinnow exports rose from 150,000 tonnes in 2003–04 (worth US$31 million) to 190,000 tonnes (worth US$39 million) in 2005–06 (an increase of 16%).

The Pakistan government has set an export target for citrus of 500,000 tonnes within the next 5 years, and $300 million in export earnings by 2013. Although Pakistan is investing in market development and infrastructure such as roads and storage facilities, some key production constraints need to be addressed to achieve these ambitious export targets.

During May 2006 ACIAR supported a Pakistan citrus industry constraints analysis, coupled with a citrus workshop, as part of the Australia-Pakistan Agricultural Sector Linkages Program (ASLP). The key constraints identified during the scoping study and by the Pakistan Horticultural Development Board (PHDEB) were: poor orchard and nursery practices; unreliable supply of certified seeds and bud wood; inefficient fruit production and irrigation practices; inadequate pest and disease management strategies (greening and canker disease); lack of cultivars and rootstocks; unavailability of seedless cultivars; overproduction and postharvest losses; lack of cold storage facilities; dysfunctional research and extension system; small-scale farming; pre-harvest contract system (advance sale to middle men); disadvantaged growers with lack of knowledge, literacy and access to information.

The study drew up a list of priority constraints for attention, and this project was designed to address them through introduction of new citrus varieties, supply chain reforms, increases in farm productivity and efficiency, and increases in fruit quality. The overall aim of this project is to improve mandarin and orange productivity in Pakistan and Australia.

The specific objectives are:

- to improve nursery production practices and production, incorporating quality assurance procedures for maintaining disease-free material, and to introduce germplasm to extend the marketing season based on matching varieties with climatic suitability to specific growing areas
- to demonstrate ‘best practice’ orchard management, focusing on tree spacing, crop management, nutrition and irrigation management
- to enhance research, extension and production capacity of Pakistan citrus institutions and industry

Project Progress

First progress report due in 2008.

HORT/2005/154: Assessment of mango diseases, pest and production problems in Pakistan

Bilateral

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	Queensland Department of Primary Industries and Fisheries, Horticulture and Forestry Science, Australia
Project Leader	Mr Robert C Williams Phone: 07 4064 1151 Fax: 07 4064 2249 Email: bob.william@dpi.qld.gov.au
Project Budget	$124,165
Project Duration	01/03/2006 to 30/06/2006
ACIAR Research Program Manager	Mr Les Baxter

Project background and objectives

The Pakistan horticulture sector is a significant supplier of domestic and exports markets. Mango is one of the major crops, with 53,443 tonnes valued at $16.54 million produced in 2000–01. This is well below expected production potential. Between 1995–96 and 2004–05 production increased by only 3.4 per cent, compared with 100 per cent increases in China and the Philippines. Pests, diseases, poor orchard management techniques and large levels of postharvest losses have all been listed as causes of low productivity. Of special concern was mango sudden death syndrome (MSDS) which has reduced productivity in some orchards by more than 20%.

This small research activity enabled an Australian study team and key Pakistani collaborators to quantify and assess the impacts of the above factors on limited productivity, in order to prioritise future research activities.

Project outcomes

This activity, an agreed priority under the Agricultural Sector Linkage Program (ASLP) between Pakistan and Australia, addressed serious productivity constraints in the Pakistan mango industry.

Key elements of the activity were:

- documentation of the current industry status and available information
- a four-day workshop for 13 Australians and 35 Pakistan participants
- eight days of field surveys and visits to R&D agencies in the main mango production regions of the Punjab and Sindh provinces by the Australian study team and key Pakistani collaborators
- detailed assessment of the background information, workshop and survey findings to develop recommendations for future R&D needs.

The documentation of the industry status provided insights into current management practices, a list of key R&D providers and a compilation of knowledge about causes and control of MSDS in Pakistan and elsewhere.

The workshop identified a number of R&D priorities for diseases and pests, orchard management and capacity building that could be investigated in an ASLP project. Topics for disease research included confirming the causes and pathogenicity of the mango sudden death syndrome (MSDS) and developing suitable strategies to control it.

For pests, it involved an economic analysis of the newly identified midge problem as well as establishing pre- and post-harvest protocols to deal with mango fruit fly issues. In orchard management, nutrition and irrigation management were singled out as the critical issues for attention to improve mango productivity, quality and reduction of MSDS incidence.

Improvement in nursery production of planting material was also identified as an area that needs urgent action to stop or slow down the re-cycling of disease and pest problems in old and new orchards.

In capacity building, training modules were identified as critical in educating growers, contractors, researchers and extension officers in different aspects of orchard management for production of quality mangoes. Other aspects of capacity building identified were the training of researchers through graduate degree programs as well as the extension of new technologies to growers through the Farmer Field School model and other suitable methods of information dissemination.

During the survey visits that followed the workshop, there were interactions between growers, researchers and other industry stakeholders, and the problems and issues facing mango production and quality in Pakistan were examined and discussed. Disease symptomatic samples as well as soil and leaf samples were collected for laboratory analysis.

MSDS was confirmed as a major production issue of concern in just about every orchard visited, averaging 3.2 trees per 10 tree sample in the Punjab and six trees per sample in the Sindh. The key issues of concern with MSDS were its early identification and procedures to stop or slow its progress in orchards. A number of pathogens were identified from field samples, including *Ceratocystis* sp. and *Lasiodiplodia* sp. Insect pests were mainly classified as a minor issue. Other major issues identified during the visits were problems of orchard management related to nutrition, irrigation, water quality and ways of synchronising tree phenology.

Detailed assessment of the background information, workshop and survey findings has identified the following key areas that will be addressed through a new ACIAR project, *Development of integrated crop management practices to increase sustainable yield and quality of mangoes in Pakistan and Australia* (HORT/2005/153) and other ASLP activities to improve industry productivity within a relatively short period (three to five years) that will deliver lasting benefits for the mango industries in Pakistan and Australia.

- Develop improved nursery systems for the production of high quality disease-free planting material.
- Develop improved tree husbandry options for the sustainable production of high quality fruit.
- Develop improved detection and management strategies for mango sudden death syndrome disease and other critical pests of mangoes.
- Build capacity in the Pakistan and Australian mango industries to conduct integrated and targeted research, development and extension programs.

10.2 Subprogram 2: Improving livelihoods of dairy farmers

Projects

Active

LPS/2005/132	Improving dairy production in Pakistan through improved extension services
PLIA/2006/136	Economic and policy constraints affecting the development of small scale dairy farmers in Pakistan

LPS/2005/132: Improving dairy production in Pakistan through improved extension services

Bilateral

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	Charles Sturt University, Australia
Project Leader	Dr Peter Wynn Phone: 02 9351 1632 Email: peterw@camden.usyd.edu.au
Collaborating Institutions	National Rural Support Program, Pakistan Punjab Livestock and Dairy Development Department, Pakistan Livestock and Dairy Development Board, Pakistan Idara-e-Kissan, Pakistan
Project Budget	$1,197,728
Project Duration	01/07/2007 to 31/12/2009
ACIAR Research Program Manager	TBA

Project background and objectives

Pakistan is the fourth largest milk producer worldwide, and dairying is by far the largest livestock sector in Pakistan. Pakistanis prefer high-fat milk, mainly produced by buffalo, with milk and/or dairy products currently providing more than half of the animal protein available for each person daily: nearly 30% of household expenditure on food items is on milk and dairy products.

Milk supply has increased by more than 5% pa over the past 15 years, but demand is anticipated to more than treble by 2020, requiring an even faster boost in production. The Government of Pakistan has national plans to increase production, raise the level of processed milk in the market to more than 30% from the current level of less than 5% (to improve product quality) and to improve the profitability to smallholder farmers (who produce over 80% of the milk) through increasing milk production per animal and streamlining marketing.

Bottlenecks in the development of the dairy sector include limitations in the extension service and the research/extension interface. There are particular problems in the style of communication between farmers and extension staff, and a lack of suitable information for extension staff to provide to farmers. There are too few extension officers, and they typically receive inadequate training. Consequently there is a failure to consider problems and solutions in a whole-of-farm systems context. The situation also places similar constraints on the research/extension or research/farmer interface.

This project, conducted under the auspices of the Australia/Pakistan Agriculture Sector Linkages Program (ASLP), is designed to address the above limitations. The research is based around two major themes:

1. support for a model system of smallholder dairy production;
2. capture and enhancement of knowledge relevant to smallholder dairy systems.

Project objectives are:

- to demonstrate the economic and social benefits of improved extension services to smallholder dairy farmers
- to enhance the scope and quality of information used for training extension personnel
- to enhance the research capacity of Pakistani scientists in priority fields relevant to the ongoing development of the dairy sector
- to promote the benefits of agency linkages and enhanced extension services to national and provincial research and extension agencies and NGO groups.

Project Progress

First progress report due in 2008.

PLIA/2006/136: Economic and policy constraints affecting the development of small scale dairy farmers in Pakistan

Bilateral

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	D.N. Harris & Associates, Australia
Project Leader	Mr David Harris Phone: 03 9889 9879, Mob: 0419 525 166 Email: dnharris@hotkey.net.au
Project Budget	$150,000
Project Duration	01/06/2007 to 30/06/2009
ACIAR Research Program Manager	Dr Jeff Davis

Project background and objectives

Industry development in the smallholder dairy sector in Pakistan has been hampered by inadequate feeding and low milk yields, low milk prices and constraints on milk marketing and distribution, and institutional and regulatory issues at all levels of government.

This small research activity has been designed to link with ACIAR project LPS/2005/132 'Improving dairy production in Pakistan through improved extension services' and address the technical issues that cause farm performance deficiencies in the smallholder sector. Its focus is to identify the economic constraints and government assistance measures that affect industry growth and farm performance improvements. It will focus on some case study communities and show the benefits of improving farm management practices.

Project Progress

First progress report due in 2008.

10.3 Subprogram 3: Management of land and water resources to sustain productive enterprises.

Projects:

Active

LWR/2000/013	Sustainable agriculture in saline environments through serial biological concentration
LWR/2002/034	Refinement and adoption of permanent raised bed technology for the irrigated maize-wheat cropping system in Pakistan
LWR/2004/035	Technology for direct drilling into rice and other heavy stubbles in Pakistan and Australia

Concluded

LWR/2005/059	Modelling water and solute processes and scenarios for optimisation of permanent raised bed systems in China, India, Pakistan and Indonesia

Pipeline

LWR/2005/144	Optimising canal and groundwater management to assist water user associations in maximising crop production and managing salinisation

LWR/2000/013: Sustainable agriculture in saline environments through serial biological concentration

Bilateral

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	Department of Primary Industries, Victoria, Institute of Sustainable Irrigated Agriculture, Australia
Project Leader	Mr Mike Morris Phone: office: 03 58335283 Fax: 03 5833 5299 Email: mike.morris@dpi.vic.gov.au
Collaborating Institutions	Pakistan Agricultural Research Council, Pakistan CSIRO Land and Water, Australia
Project Budget	$807,557
Project Duration	01/01/2004 to 31/12/2007
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

The combination of irrigation-based agriculture and arid climates in parts of Pakistan and Australia has seen an unintended consequence – salinity. This is caused when naturally occurring salt, found in soil, is mobilised by rising water tables. The resulting discharge into top soils results in agricultural management for salt drainage or reduction, rather than production. Without this approach, however – either through saline effluent drainage, use of salt tolerant species or effective evaporation – the land becomes unproductive.

Drainage can cause negative impacts to downstream users, shifting the problem rather than alleviating it. Evaporation also has drawbacks, working best for small quantities of water only. Discontinuing irrigation will not remove existing salt, nor ensure the continued agricultural viability of the land. Options for disposing of saline effluent, by rivers or through conjunctive groundwater processes are often difficult.

Combining options, releasing some saline effluent and capturing the heaviest salt load in a small quantity of effluent then diverted to an evaporation basin, is the best approach. Achieving this, in conjunction with existing and new measures can greatly increase the agricultural versatility of the affected land.

Serial biological concentration (SBC) systems can play a central role in achieving this. The system is based on the continued reuse of saline effluent, flushing it through a series of biological chains. Each chain concentrates the effluent further by significantly reducing the volume of water but not the salt content. Effluent is cascaded through the chains, made up of plants and crops, until the heavily salted remainder is directed to an evaporation basin. Water use is maximised but saline residues in the soil reduced. Salt harvesting and the use of salt tolerant agriculture (for instance aquaculture of tolerant fish) offer potential income. SBC is already under trial in Australia at two locations in the Murray Darling Basin; part of a total approach to salinity management.

Proving the concept of SBC in appropriate areas of Pakistan for its incorporation into existing salinity management systems is underway in this project.

Project Progress

Year 3 (01/01/2006–31/12/20060

Objective 1: Establish and test as a proof of concept SBC technology at two sites in Pakistan (Punjab and Sindh)

Demonstration sites were established in Sindh (near Thatta) and Punjab (near Bhalwal) during 2005. By the start of 2006 both sites had been sown to a wheat crop on all SBC stages. The crop at Thatta was subsequently lost due to flooding. Our visit in March identified operational improvements needed at each site.

- At Thatta the monitoring of water and salt flows and the operation of the sumps needed improvement. Stage B was not yet in production and a significant weed problem (canegrass) was apparent.
- At Bhalwal the tile drains were found to be blocked with silt. Limited sump volume below the drainage collector pipes was identified as a probable contributing factor because the drainage laterals could not be maintained in a freely draining state.

Programs for improving management and monitoring prior to sowing the next crop were developed with the managers at each site. At the Bhalwal site attempts were made during April and May to clear the tile drain laterals, but without success. Monitoring data and soil EC profile data clearly indicated that there was insufficient rootzone drainage occurring in each stage and that there was insufficient drainage water from each stage to meet the crop water requirement of the next stage. In June the tile drainage system was replaced by two skimming wells, one located in the centre of Stage A supplying irrigation to Stage B, the other in the centre of Stage B supplying irrigation water to Stage C.

Both sites were sown to rice on all stages for the kharif season. Rice was chosen because

- it is a common and valuable kharif crop local know how to grow
- it is tolerant of inundation, likely to occur at the Thatta site in particular, and
- ponding could help reclaim the sites by leaching salt from the rootzone.

The Australian team's visit in September highlighted further issues at both sites, which were detailed in the subsequent travel report. In summary, the site management at Bhalwal was of a high standard. The rice crop was variable but generally growing well. Soil profile ECs indicated that rootzone leaching was occurring, however the skimming wells installed in June had been installed too deeply for SBC. At Thatta the site management was poor. The site had recently been inundated and surface water control was ineffective, subsurface drainage was inadequate. There was very limited measurement of water flows on and off Stages. The crop was poor and weed infested.

A detailed work plan was developed for the Thatta site. Australian team member Shahbaz Khan subsequently visited the Thatta site in late December and noted that the work program was being implemented, with significant improvements to the water management and weed control. A wheat crop had been successfully established on Stage A, and barley on Stages B and C.

Objective 2: Analyse the financial viability of SBC in Punjab, Sindh and the Murray Darling Basin.

A financial model for SBC developed for the Murrumbidgee region was assessed in 2005 to be a very suitable tool that could be adapted for wider application in the Murray Darling Basin and Pakistan. In 2006 the tool has been adapted for wider use on the Murray Darling Basin and has been applied to an evaluation of SBC for management of saline flows in Box Creek, NSW.

Objective 3: Assess the scope for adoption of SBC technology in the irrigation areas of the Murray Darling Basin.

A Geographical Information Systems (GIS) based approach was used in regional suitability analysis, using estimates of thresholds for the SBC suitability criteria in three irrigation areas (Murrumbidgee Irrigation Area (MIA), Shepparton Irrigation Region (SIR) and the Murray Irrigation Limited (MIL) Area in the MDB. The main aim of the analysis was to provide a coarse scale ranking of the relative suitability of land for SBC application within the regions. Here we only considered the main physical factors for defining the suitability thresholds. Socio-economic factors associated with SBC application such as loss of land, proximity to roads and facilities have not been considered in this analysis. SBC suitability maps for MIA and SIR are now available. These maps are being further refined by using alternative indices combining water table, salinity and soils data.

Objective 4: Develop an analytical framework to assist in the selection of the best management system for a range of saline drainage effluents.

A salinity management Knowledge Integration Framework has been developed using a Bayesian network approach. The framework captures and integrates knowledge about salinity management and supports strategic decisions on how to manage salt at a range of scales. The framework was developed by a technical working group of acknowledged experts who, in an iterative series of workshops, developed an agreed conceptual representation of the regional groundwater system in the form of a cause-and-effect diagram.

The process followed was:

1. collate existing knowledge
2. identify key outcome measures for salt management
3. develop a conceptual representation of the system
4. identify knowledge gaps and areas of uncertainty in current understanding
5. test impacts and identify risks of current management strategies.

The framework and process used to develop it have proved to be very beneficial. There is now agreement and common understanding of the whole system by senior irrigation water supply engineers, catchment managers, researchers and policy makers. Discussions are now more focused, but at the same time consider the whole system.

In the Shepparton Irrigation Region the framework has been used to identify thirty knowledge gaps in our current understanding of groundwater management impacts on the shallow groundwater system. It has also been used to identify and prioritise potential risks from the disposal of subsurface drainage to irrigation supply channels and surface drains.

Outcomes of the work have included:

- enhanced knowledge exchange and collaboration between the Department of Primary Industries and Goulburn-Murray Water
- restructure of Subsurface Drainage Coordinating Group meetings to incorporate technical forums for strategic thinking
- reprioritisation of the Research and & Investigations Strategy, with the inclusion of additional issues identified through the Knowledge Integration Framework.

LWR/2002/034: Refinement and adoption of permanent raised bed technology for the irrigated maize-wheat cropping system in Pakistan

Bilateral

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	Department of Agriculture and Food, Western Australia, Australia
Project Leader	Mr Greg Hamilton Phone: 08 9368 3276 Fax: 08 9368 3355 Email: ghamilton@agric.wa.gov.au
Collaborating Institutions	Pakistan Agricultural Research Council, National Agriculture Research Centre, Pakistan
Project Budget	$465,478
Project Duration	01/01/2004 to 30/06/2007 (Project extended from 01/01/2006 to 30/06/2007)
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

Agriculture in Pakistan is dominated by irrigated cropping, with more than 80 per cent of cultivated land relying on some form of irrigation. Much of this land is suffering from substantial productivity declines. Estimates put this as high as 25 per cent of gross production. Grain yields in irrigated cropping are low. Water use practices and inappropriate soil contribute to low levels of efficiency in water use.

The combination of irrigation practices and poorly suited soils is resulting in water-logging and low levels of salinity, causing productivity declines. Rising water tables caused by seepage losses from canals, watercourses and deep drainage beneath flooded irrigated fields will increase water-logging and salinity.

Cropping intensity is another reason for declining produce levels. Inadequate water allocations often result in fields being fallow for up to 12 months. These bare fallow periods followed by excessive cultivation are reducing soil organic matter and weakening soil structures.

A previous ACIAR-funded project demonstrated how permanent raised cropping beds (beds formed between furrows for traffic and left for at least five years before ploughing or reforming) could lift yields. Maize yields rose by 35 per cent and wheat by 20 per cent. Irrigation was reduced, resulting in less water seeping into soils and lessening negative impacts on soil structures.

The project is quantifying the benefits of permanent raised bed cropping in Pakistan and promoting its adoption.

Project Progress

Year 3 (01/01/2006–31/12/2006)

Research Production changes

Average yields for each treatment over the two wheat crops and two maize crops have been compounded by disease outbreaks and water supply difficulties. Notwithstanding these difficulties, the permanent bed treatments have out-yielded the basin treatment in all four cropping seasons. Averaged over the four years the PRB treatments have yielded 8% more than the basin treatment.

When production is viewed in terms of ease with which plants use the applied irrigation water (kg/ha/mm of irrigation), the benefit of PRBs is more clear-cut and consistent. For every mm of water applied the:

- Wide beds – depletion replacement irrigation treatment produced 27kg/ha
- Wide beds – district practice irrigation treatment produced 25kg/ha
- Narrow beds – depletion replacement irrigation treatment produced 19kg/ha
- Narrow beds – district practice irrigation treatment produced 20kg/ha
- Basin – flood irrigation treatment produced 16kg/ha.

The results clearly show that furrow-irrigated PRBs produce substantial yield increases and water savings over traditional flood-irrigated Basins. Both these benefits combine to produce a substantial increase in income and profitability.

Irrigation changes

Because of the easier uptake of water from the more conservatively managed soil, less water is needed by the permanent Wide Bed treatments. In addition to these soil-condition improvements in irrigation, there is clear evidence that irrigation scheduling, which aims to apply only the amount of water used by plants, further reduces the amount of irrigation water required to grow highly productive crops. Relative to the water applied to the district practice of flooding Basins, average savings in water applied to wheat and maize crops on the different types of beds and irrigation practice are:

- Wide beds – depletion replacement irrigation 35%
- Wide beds – district practice irrigation 28%
- Narrow beds – depletion replacement irrigation 4%
- Narrow beds – district practice irrigation 1%

Deep drainage changes

Deep drainage losses, which arise when water drains beyond the root zone of crops causing water tables to rise and waterlogging and salinity to increase, are least under wide permanent raised beds, moderate under narrow bed and greatest under Basins. This assessment is based on the time free-water stands on the basin or in the furrows; the proportion of land on which free-water stands and the hydraulic conductivity of the soil on which the free-water stands. Relative to Basin conditions, deep drainage losses are 50% less for the Narrow Beds and 90% less for the Wide Beds.

Soil changes

Soil that is managed with the least amount of disturbance will eventually have properties that improve water and air movement, root proliferation and plant nutrition. Although these changes take time to become measurable and significant, clear trends have emerged in our data that illustrate these advantages are occurring. Soil conditions in the Wide Beds are better than those in Narrow Beds, which are better than those in the Basins.Soil density is less in the PRBs. Wetting front penetration is greater in the PRBs. Water movement beneath the PRBs treatments is less. Plant water extraction is greater in the PRBs toward the end of the season. PRBs contain more organic matter than the Basins.

Adoption

Adoption of PRB farming practices has been stimulated by creating groups of farmers to share the use and purchase of PRB bedformers and seeders. In August 2004, two Cluster groups were formed and repayment agreements signed for interest-free, time-payment purchase of Australian-made machinery. The Cluster groups are led by two respected members of the local farming community, Feroz Shah and Nobat Kahn.

A reasonably large number of farmers in each group Cluster has used the machines and PRB farming practices to grow crops by every season since August 2004, wheat in 2004–05, maize in 2005, wheat in 2005–06 and maize in 2006. Currently the 2006–07 wheat crop is being grown. The numbers of farmers using PRBs for maize cropping in 2005 and 2006 was 15 and 23 in Shah's group, and 23 and 16 in Khan's group. The number of farmers growing wheat on PRBs is less – 12 and 23 in Shah's group and 10 and 8 in Khan's group in 2004–05 and 2005–06.

Average farmer yields have been reasonable but much less than the research yields: The farmers' average maize yield is 4.65 t/ha compared to the research yield of 7.93t/ha; and their average wheat yield is 3.09t/ha compared to 4.49t/ha. The reasons for the farmers' lower production are being investigated.

Long-term adoption of this technology relies on locally made and serviced machinery being readily available at an acceptable price, but so far local manufacturers have failed to make machines of an acceptable quality and performance. Efforts to source locally made machinery of an acceptable standard are continuing

LWR/2004/035: Technology for direct drilling into rice and other heavy stubbles in Pakistan and Australia

Bilateral

Overseas Collaborating Countries	Pakistan
Commissioned organisation	CSIRO Land and Water, Australia
Project Leader	Dr Shahbaz Khan Phone: 02 6960 1578 Mobile: 0409 984 076 Email: shahbaz.khan@csiro.au
Collaborating Institutions	Pakistan Agricultural Research Council, Farm Machinery Institute, Pakistan
Project Budget	$399,998
Project Duration	01/10/2005 to 30/09/2008
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

Burning is the normal method of rice stubble management in the 2 million ha of rice-wheat (RW) systems of Pakistan, and in the 0.15 million ha of rice-based cropping systems of southern Australia. In southern Australia most irrigated wheat and 50% of maize stubbles are also burnt. Stubble burning causes air pollution (particulates, greenhouse gases), nutrient loss (especially N and C, also P, K and S) and soil organic matter decline. In Pakistan, air pollution from stubble burning is particularly bad, impacting on human health.

Until recently there has been no machinery capable of direct drilling into rice stubble and achieving consistently good results, due to problems of clogging of tool bars with the loose residues and hair pinning. These problems were recently overcome with the development of the Happy Seeder concept, which involves cutting and picking up the stubble, sowing into bare soil, and mulching with the stubble in a single operation.

While the problem of sowing into heavy residues has almost been solved mechanically, experience to date in India shows that there are some design parameters and agronomic management practices that need to be refined to achieve good establishment and crop performance with the Happy Seeder approach. These include evenness of spreading of the mulch, amount of mulch that a crop can establish through, sowing depth, soil moisture at sowing, soil type and irrigation and nitrogen (N) management.

There is clearly a need to evaluate and refine the technology for a range of stubble, soil and seasonal conditions, and to develop guidelines for achieving reliably good establishment, efficient use of N fertilizer and high yields in RW and alternative cropping systems.

Objective 1: To evaluate and refine the Farm Machinery Institute (FMI) seeder in Pakistan, and the Twynam Happy Seeder in Australia, for direct drilling into rice and other heavy stubbles.

Objective 2: To enable the manufacture of FMI Seeders in Pakistan, and to extend the uptake of the new direct drilling technology by farmers in Pakistan and Australia.

Project Progress

Year 1 (01/10/2005–30/09/2006)

The project activities started on time (October 2005) in Pakistan and Australia, although there was a delay in release of funds in Pakistan. Despite these difficulties, the project has made some good achievements, due to the determination and dedication of key project staff.

Major achievements include:

1. Construction of Mark III of the FMI seeder, in time for sowing in mid-November 2005; however some modifications were needed, and consequently most of the experimental sites were sown with Mark II. The main improvements in Mark III are reduced weight (~550 kg) and improved operator visibility and straw spreading.

2. Installation of three unreplicated large plot (mostly 0.5 acre) trial sites in farmers' fields in Pakistan, comparing establishment methods, and a replicated experiment with establishment method as the main plots, and N rate sub-plots. Establishment methods included sowing into rice residues (~8 t/ha) and partially burnt plots with the FMI seeder. These were compared with conventional practice (partial burning then disc harrowing then broadcast seeding) and sowing into fields with the zero till drill after manual removal of all the rice straw.

   Establishment was generally good in all plots/treatments, except in some low lying areas affected by waterlogging. Yields were around 3 t/ha, and there were no significant differences between establishment method, suggesting that there is no disadvantage of sowing into full rice residues with the FMI seeder. This is a good result in the first year.

3. Successful establishment of soybeans in 4.5 t/ha of barley residues and barley in 10 t/ha of maize residues in Australia using the Combo Happy Seeder imported from India.

4. Several field days and presentations to farmers in both Pakistan and India, piggy-backing on activities largely organised by other groups in both countries e.g. the ADB/IRRI Rice-wheat project in Pakistan, and NSW DPI activities in Australia. Key policy makers and influencers in Pakistan (the DGs of PARC, NARC and Punjab OFWM) have already been familiarised with the technology and most have visited some of the field sites.

LWR/2005/059: Modelling water and solute processes and scenarios for optimisation of permanent raised bed systems in China, India, Pakistan and Indonesia

Bilateral

Overseas Collaborating Countries	China, India, Indonesia, Pakistan
Commissioned Organisation	CSIRO Land and Water, Australia
Project Leader	Dr Freeman Cook Phone: (07) 3214 2840, Mob: 0409 613 932 Fax: (07) 3214 2855 Email: freeman.cook@csiro.au
Project Budget	$84,816
Project Duration	01/04/2006 to 30/09/2007 (Project extended from 01/07/2007 to 30/09/2007)
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

Permanent raised beds are being used to minimise the effects of water logging, reduce irrigation water and improve the biological and physical health of the soils; all these factors leading to increased productivity of crops. Design criteria for permanent beds in terms of infiltration and drainage are not well developed and are usually driven by machinery specifications. Fertiliser placement for nutrient and solute management and the risk of build-up salts are additional criteria to be addressed by country partners.

This project will underpin existing ACIAR projects by helping develop design criteria for optimising bed design from analytical and numerical modelling of water and solute transport; design fertiliser placement strategies to maximise fertiliser usage and minimise leaching to ground water; and determine whether salinisation is likely with time in some soil/bed configuration/climate/water quality scenarios. It will do this using two-dimensional water and solute modelling.

Project Outcomes

Final report not yet submitted by the Commissioned Organisation.

10.4 Other Projects:

Projects:

Active

CIM/2003/067	Ensuring productivity and food security through sustainable control of yellow rust of wheat in Asia

CIM/2003/067: Ensuring productivity and food security through sustainable control of yellow rust of wheat in Asia

Multilateral

Overseas Collaborating Countries	Afghanistan, Bangladesh, China, India, Pakistan
Commissioned Organisation	International Maize and Wheat Improvement Center, Mexico
Project Leader	Dr Ravi Singh Phone: 52 55 58042004 Fax: 52 55 58047558 Email: r.singh@cgiar.org
Collaborating Institutions	University of Sydney, Australia International Center for Agricultural Research in the Dry Areas, Syria Global Overseas Collaborators, Global
Project Budget	$1,000,050
Project Duration	01/01/2005 to 31/12/2009
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Wheat is a widely grown crop throughout many parts of Asia. Of the total worldwide areas planted to wheat more than 40 per cent is grown in Asia where it is an important staple food crop. Of the 95 million hectares devoted to wheat cropping almost half this area (some 43 million hectares) is susceptible to stripe rust.

Stripe rust's causal agent, *Puccinia striiformis tritici (Pst)*, can spread rapidly. It is capable of air-borne migration being carried long distances by wind. The agent can also evolve rapidly into new wheat races (those of a common ancestry). Growing numbers of wheat races have proven susceptible to yellow rust. Once wheat resistant gene, *Yr9*, present in several wheat races, in South, West and Central Asian countries has begun to break down, resulting in millions of dollars of losses from rust.

Current control measures, fungicides applied at the appropriate time in the cropping cycle, are adequate. These have, however, environmental and price constraints, causing pollution and adding to production costs. Growing new varieties with rust resistance is likely to produce the most successful control option, also addressing cost and environmental constraints. The ability of rust to travel distances, invade new races and break down resistant genes will require the identification and breeding of lines with a new genetic basis for resistance, the subject of this work.

The aim of this project is to increase the food security and profitability of wheat production systems in several countries of Asia and to protect the environment and human health through strategies contributing to the sustainable control of yellow rust disease of wheat.

Project Progress

Year 2 (01/01/2006–31/12/2006)

ACIAR funding supports ongoing and new research and capacity building activities at CIMMYT, ICARDA, and PBIC-Sydney University to ensure productivity and food security through sustainable control of wheat yellow rust, caused by *Puccinia striiformis tritici* (Pst), in Asia. Development of new near-isogenic lines (NIL) for greenhouse and field monitoring for genes Yr2, Yr3, Yr4, Yr33, Yr34, Yr35, Yr36 is progressing to fill the gaps in the existing NIL set. NIL for gene Yr8 purified and multiplied and for Yr17 purified. Specific gene combinations are also under progress.

Data from Yellow Rust Trap nurseries planted at key sites in South Asia, China and CWANA regions indicate significant variations in Pst populations in these areas. Virulence for Yr17, first detected in Central Asia, is now widely spread. Increasing virulence for Yr3 and its distribution in Pakistan and Afghanistan is a threat to the variety 'Tatara' the sown area of which has increased recently after the epidemic on 'Inquilab 91' during 2005.

Lack of virulence for some genes that were ineffective previously is a major concern to progress in yellow rust breeding.

A unified Yellow Rust Trap Nursery will now be planted in all countries except China which forms a different epidemiologic region with very different cultivars.

Several facultative/winter wheat cultivars grown, or newly released, in various countries of the CWANA region indicated that only a few were resistant at all sites except in Pakistan. This further demonstrated their vulnerability to diverse pathotypes predominant in different areas. Seedling gene postulation work on Central Asian cultivars conducted in Australia identified some of the commonly occurring genes, which have little or no value to provide resistance to some of the races known to occur in the region.

Evaluation in Mexico of individual F2 derived-F5 lines from crosses of yellow rust susceptible Avocet with four Chinese cultivars that show moderate levels of resistance in China but immunity in Mexico confirmed F3 results that each cultivar carried 1 major gene and 2–3 minor genes.

Significant progress was made in incorporating durable resistance into several cultivars from China. Because these Chinese cultivars are highly resistant in Mexico but either susceptible or moderately resistant in China, we used a shuttle breeding strategy to speed up the breeding as well as select under high yellow rust pressure in China.

During 2006 we identified 119 advanced lines with yellow rust resistance and desirable agronomic traits and planted them in replicated yield trials in farmers' fields during the 2006–07 season. Selections were done on 62 new BC1-derived-F5 populations involving 13 additional Chinese cultivars from Sichuan and Yunnan provinces during 2006 in Chengdu and over 1000 advanced lines were planted for further evaluation and selection during 2006–07. An additional 94 F4 populations were planted in Chengdu and Kunming following selection in the F2 and F3 generations in Mexico.

The '1st Elite Bread Wheat Yield Trial', containing 28 high-yielding entries with resistance to rusts, was grown at a total of 16 sites in India, Pakistan, Afghanistan, Iran and Turkey to find replacements for cultivars that are now susceptible to new races of yellow rust. Several new lines showed significantly higher yield potential and resistance at most of the sites in each country and were selected by the co-operators for further testing. Seed of high yielding entries for the '2nd Elite Bread Wheat Yield Trial' was multiplied during 2006 and planted at 30 sites in 11 countries. About half of the entries have shown high to moderate levels of resistance to the Ug99 race of stem rust pathogen.

Incorporation of yellow rust resistance in 21 facultative/winter wheat cultivars from Central Asian countries has been progressing well in Mexico. Populations in various generations from F1 to F3 were planted for either backcrossing or selection under yellow rust pressure in the 2006–07 winter season at Toluca, Mexico.

A training course was organised in Uzbekistan for 20 scientists, mostly from Central Asia, to enhance their capacity in managing rust diseases of wheat and breeding for resistance. A Chinese scientist, Mr. Huazhong Zhu, attended a 3-month advanced training course on wheat improvement in Mexico. R.P. Singh, C. Wellings and A. Yahyaoui interacted with various scientists during visits to various breeding and pathology programs in China and Central Asia.

PART 3: BANGLADESH

11 Annual Report 2006-07

Active projects in 2006-07	7
AOP budgeted expenditure in 2006-07	$405,500
Actual expenditure in 2006-07	$413,045
Expenditure in 2005-06	$371,464
Expenditure in 2004-05	$243,712

Key performance indicators	Performance 2006-07
Technical and economic feasibility of wheat production examined in southern Bangladesh, and options for further research and development determined	The study confirmed the long term financial and technical feasibility of growing wheat as a rabi season crop on residual moisture. ACIAR commissioned a project to underpin the further expansion of wheat into rice-fallow systems, with strong participation of NGOs.
Integrated legume research program designed and initiated	Project aimed at expanding production of rabi season chickpeas and lentils initiated in NW of Bangladesh.

11.1 Position

Bangladesh has been a partner country since the mid-1990s. ACIAR's program is small, given Australia's relatively limited comparative advantage to deal with Bangladesh's rice-dominated agricultural problems.

Projects have focused on constraints to broadacre crop production (especially the rice–wheat cropping system) and potential for increased inclusion of a legume component in cropping systems. One project addresses diseases of these legumes.

A completed project on management of Hilsa fisheries led to a series of management recommendations which will require difficult decisions to be made by the Government if the fishery is not to risk collapse. Most recently a project analysing the fate of arsenic from groundwater has produced useful information that has contributed to a larger initiative on the arsenic problem in Bangladesh.

11.2 Achievements

Current collaboration is mainly in the production and management of grain crops. Botrytis grey mould (BGM), considered the most important foliar disease of chickpeas in Bangladesh, has caused a substantial decline in chickpea production over the past decade. A project has screened a wide range of chickpea germplasm (including closely related wild species) for resistance to BGM under field conditions in Bangladesh and Nepal to provide a sound basis for genetic enhancement of host plant resistance to BGM.

Field screening to identify chickpea lines with resistance to BGM took place in Bangladesh over four seasons. There were clear differences in reaction to BGM, as measured on a 1 to 9 rating scale at each location in all seasons. A series of on-farm trials was conducted in Bangladesh to evaluate various components of disease and crop management under farmers' conditions and merge them with the evolving integrated crop management (ICM) package for chickpea.

Using the results gathered in the 2002–03 season the project has assembled ICM packages, incorporating best-bet technologies for BGM management along with other optimum agronomic packages, and these have been tested in farmer-managed operational scale plots and compared with adjacent plots where prevailing farmers' practice was followed. The trials found yield increases in five districts due to ICM were around 20–50%.

In the past, lands in southern Bangladesh were considered too risky for rice–wheat rotations because of the hot, short-season rabi (dry season) environment and, in some districts, the saline soil profile and limited water resources. Only recently have these southern lands been reconsidered for rabi-season production of crops such as wheat, maize and mungbean, using supplementary irrigation from limited surface water stored over from the wet kharif season.

ACIAR funded a scoping study to assess the long-term technical and economic feasibility of rabi wheat production. The study provided justification for continued R&D investment in rabi-season crops on currently fallow lands in southern Bangladesh. Specifically, the study noted that water resources of southern Bangladesh needed to be characterised to determine their potential availability for irrigation, their distribution, and the types of water bodies and their quality. Salinity levels have the potential to affect wheat production, and tolerance of current and improved varieties to salinity needs further investigation.

Further work is also needed to adapt agronomic practices, especially the timing and amounts of fertiliser and irrigation, in order to increase ecological sustainability, profitability and yield.

12 Annual Operational Plan 2007-08

GNI per capita ($US)	470
Population	139.2 million
Population 2015/2050	168.2/242.9 million
Active bilateral projects	3
Active multilateral projects	1

Bilateral actual 2005–06	$ 0.37 m
Bilateral estimate 2006–07	$ 0.41 m
Bilateral budget 2007–08	$ 0.46 m
Bilateral + multilateral budget 2007–08	$ 0.53 m

12.1 Key performance indicators (2007–08)

- Extent of water resources available for supplementary irrigation to facilitate expansion of rabi cropping in southern Bangladesh determined
- Improved crop establishment techniques for legume planting in north-western Bangladesh designed and tested

12.2 Medium-term strategy

ACIAR's strategy in Bangladesh is to focus on agronomic and biotic constraints to the production of broadacre grain crops, especially the 'rabi' or winter season crops, either through bilateral projects or projects led by IARCs that link to existing programs such as the CGIAR-coordinated Rice–Wheat Consortium.

12.3 Position

Bangladesh has been a partner country since the mid-1990s. ACIAR's program is small, in view of Australia's relatively limited comparative advantage to deal with Bangladesh's rice-dominated agricultural problems.

Projects have focused on constraints to broadacre crop production (especially the rice–wheat cropping system) and potential for increased inclusion of a legume component in cropping systems.

One project addresses diseases of these legumes. An earlier fisheries project now completed studied management of the Hilsa fishery. It led to a series of management recommendations that will require the Bangladeshi Government to make difficult decisions to save the fishery from collapse.

Most recently a project analysing the fate of arsenic from groundwater produced useful information that contributed to a larger initiative on the arsenic problem in Bangladesh.

12.4 Indicative priorities

Priorities for collaboration are developed through visits of research program managers and other senior staff, meeting with managers and scientists at agricultural R&D institutions and government bodies.

Current collaboration is mainly in the production and management of grain crops. In the medium term, ACIAR will consider projects in the area of agronomic and biotic constraints to the production of broadacre grain crops.

13 Projects (summary and progress reports)

Projects:

Active	
CIM/2003/067	Ensuring productivity and food security through sustainable control of yellow rust of wheat in Asia
CIM/2004/003	Plant health management for faba bean, chickpea and lentils
CIM/2007/027	Development of conservation farming implements for two-wheeler tractors (power tillers) in Cambodia, Laos and Bangladesh
LWR/2005/001	Addressing constraints to pulses in cereals-based cropping systems, with particular reference to poverty alleviation in north-western Bangladesh
LWR/2005/146	Expanding the area for Rabi-season cropping in southern Bangladesh
Concluded	
CIM/2001/039	Integrated management of Botrytis Grey Mould of chickpea in Bangladesh and Australia
LWR/2005/042	Scoping study to assess the technical and economic feasibility of wheat production in southern Bangladesh
Pipeline	
CIM/2006/185	Diversification of cropping systems in Bangladesh by improving and expanding lentil production.

CIM/2003/067: Ensuring productivity and food security through sustainable control of yellow rust of wheat in Asia

Multilateral

Overseas Collaborating Countries	Afghanistan, Bangladesh, China, India, Pakistan
Commissioned Organisation	International Maize and Wheat Improvement Center, Mexico
Project Leader	Dr Ravi Singh Phone: 52 55 58042004 Fax: 52 55 58047558 Email: r.singh@cgiar.org
Collaborating Institutions	University of Sydney, Australia International Center for Agricultural Research in the Dry Areas, Syria Global Overseas Collaborators, Global
Project Budget	$1,000,050
Project Duration	01/01/2005 to 31/12/2009
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Wheat is a widely grown crop throughout many parts of Asia. Of the total worldwide areas planted to wheat more than 40 per cent is grown in Asia where it is an important staple food crop. Of the 95 million hectares devoted to wheat cropping almost half this area (some 43 million hectares) is susceptible to stripe rust.

Stripe rust's causal agent, *Puccinia striiformis tritici (Pst)*, can spread rapidly. It is capable of air-borne migration being carried long distances by wind. The agent can also evolve rapidly into new wheat races (those of a common ancestry). Growing numbers of wheat races have proven susceptible to yellow rust. Once wheat resistant gene, *Yr9*, present in several wheat races, in South, West and Central Asian countries has begun to break down, resulting in millions of dollars of losses from rust.

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The aim of this project is to increase the food security and profitability of wheat production systems in several countries of Asia and to protect the environment and human health through strategies contributing to the sustainable control of yellow rust disease of wheat.

Project Progress

Year 2 (01/01/2006–31/12/2006)

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Significant progress was made in incorporating durable resistance into several cultivars from China. Because these Chinese cultivars are highly resistant in Mexico but either susceptible or moderately resistant in China, we used a shuttle breeding strategy to speed up the breeding as well as select under high yellow rust pressure in China. During 2006 we identified 119 advanced lines with yellow rust resistance and desirable agronomic traits and planted them in replicated yield trials in farmers' fields during the 2006–07 season. Selections were done on 62 new BC1-derived-F5 populations involving 13 additional Chinese cultivars from Sichuan and Yunnan provinces during 2006 in Chengdu and over 1000 advanced lines were planted for further evaluation and selection during 2006–07. An additional 94 F4 populations were planted in Chengdu and Kunming following selection in the F2 and F3 generations in Mexico.

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Seed of high yielding entries for the '2nd Elite Bread Wheat Yield Trial' was multiplied during 2006 and planted at 30 sites in 11 countries. About half of the entries have shown high to moderate levels of resistance to the Ug99 race of stem rust pathogen.

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A training course was organised in Uzbekistan for 20 scientists, mostly from Central Asia, to enhance their capacity in managing rust diseases of wheat and breeding for resistance. A Chinese scientist, Mr. Huazhong Zhu, attended a 3-month advanced training course on wheat improvement in Mexico. R.P. Singh, C. Wellings and A. Yahyaoui interacted with various scientists during visits to various breeding and pathology programs in China and Central Asia.

CIM/2004/003: Plant health management for faba bean, chickpea and lentils

Bilateral

Overseas Collaborating Countries	Bangladesh
Commissioned Organisation	International Center for Agricultural Research in the Dry Areas, Syria
Project Leader	Dr Ashutosh Sarker Phone: 963 21 225012/225112, /234890 Fax: 963 21 225105/213490 Email: sarker@cgiar.org
Collaborating Institutions	NSW Department of Primary Industries, Australia Centre for Legumes in Mediterranean Agriculture, Australia Department of Primary Industries, Victoria, Australia University of Adelaide, Australia International Centre for Agricultural Research in the Dry Areas, Bangladesh
Project Budget	$398,916
Project Duration	30/06/2004 to 30/06/2008 (Project extended from 01/07/2007 to 30/06/2008)
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Providing high-quality, but low-cost protein in human diets is especially important in many developing countries. For the poor, especially those unable to afford animal-based products as a source of dietary protein, food legumes provide quality protein at an affordable cost. The legumes chickpea, faba bean and lentil are the most important grown in sub-tropical dry areas, offering farmers cheap and easily available protein.

Legume crops have a higher value than cereals and generally produce more for harvest in the same area of land as other cereals, offering poor farmers additional income. Food legumes also fix atmospheric nitrogen into soils, providing an alternative to fertilisers as a means to boost yields. In addition they also reduce the inoculum build-up of cereal diseases in soil. Despite this value diseases can still substantially limit production. Control options are generally expensive and not viable for smallholder or poor farmers.

ICARDA, with a mandate to improve legume production, will examine options both for germplasm improvement and plant management methods and technology applicable for poor smallholders. It is building on the achievements of past research, focussing on screening and exchange of germplasm.

Project Progress

Year 2 (30/06/2005–29/06/2006)

- Several additional new sources of resistance to major diseases affecting pulse crops were identified at ICARDA and will be shared with the Australian and other national breeding programs.
- Additional Australian pulse varieties and advanced breeding lines have been exposed to exotic pathogens and diverse pathogen populations. This permitted pre-emptive screening for diseases not yet encountered in Australia such as chickpea and lentil *Fusarium* wilts.
- Efforts were made by Australian breeding programs to improve the levels and deployment of resistance to major diseases prevailing in Australia.
- At ICARDA, over 200 isolates of *Ascochyta fabae* were collected in Syria, single-spored, characterised morphologically, and are currently being analysed using molecular markers.
- A refined methodology for efficient screening of chickpea for resistance to *Ascochyta* blight was developed at ICARDA, using alternative sources of inoculum and different inoculation timings.

- Three emerging new diseases (*Stemphylium* blight in lentil, *Cercospora* leaf spot and Tomato wilt spotted virus in faba bean) are under investigation in Australia. Chickpea *Fusarium* wilt and cyst nematode are gaining importance in Syria.
- The work at the University of Adelaide and SARDI explored options for the management of the new emerging disease on faba bean, *Cercospora* leaf spot, including the identification of resistant breeding lines.
- The work at CLIMA continues to improve the IDM package for the control of chickpea *Ascochyta* blight.
- Screening of lentil and chickpea germplasm for resistance to *Botrytis* grey mould at DPI-Horsham in 2005 revealed a wide range of reactions to *Botrytis* grey mould. Results were encouraging with the breeding of *Botrytis* grey mould resistant lines expected in the near future. Lines having the Canadian cultivar 'Indianhead' as a parent appeared to be most resistant to infection by *Botrytis* spp.

CIM/2007/027: Development of conservation farming implements for two-wheeler tractors (power tillers) in Cambodia, Laos and Bangladesh

Bilateral

Overseas Collaborating Countries	Bangladesh, Cambodia, Laos,
Commissioned Organisation	Australia
Project Leader	Mr R J Esdaile Phone: 02 6760 8572, Mob: 0427 608 572 Email: rjesdaile@bigpond.com
Project Budget	$46,500
Project Duration	01/06/2007 to 31/03/2009
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Tillage operations by the majority of smallholder farmers in parts of South and Southeast Asia have until recently relied on manual and animal draught power. In the last decade, mechanisation based on the use of two-wheel tractors (power-tillers) has become widespread. The versatility of power-tillers offers significant opportunities to promote conservation tillage in areas of Asia that are transitioning into mechanised agriculture (e.g. Bangladesh, Burma, Cambodia and Lao DPR).

However, with the exception of work carried out by CIMMYT in Bangladesh from 1995 to 2004, to develop conservation tillage implements for power-tillers to establish wheat in rice–wheat systems, little further systematic design, development and testing work has been carried out. This is partly because conservation tillage research has tended to focus on four-wheel tractors (e.g. Pakistan, India, China), or there is limited research capacity to develop agricultural machinery (e.g. Burma, Cambodia and Lao DPR).

A factor compounding the difficulty to develop and promote conservation farming implements for two-wheel tractors is the lack of machinery standardisation between the different power-tiller manufacturers. Consequently, unavailability of suitable conservation farming implements to match prevailing two-wheel tractors in many Asian countries represents a major constraint to the promotion and adoption of conservation farming techniques where mechanisation is primarily at the power-tiller level.

This Small Research Activity aims to bridge this constraint by providing ongoing ACIAR projects in Cambodia, Laos and Bangladesh with a suite of conservation farming implements suitable to use with power-tillers prevalent in the respective countries, and to build these activities into the planning of new projects.

The specific objectives to achieve this are:

1. to develop a universal toolbar complete with a set of conservation farming attachments (including both full tillage and zero tillage seed drills) that can be used on a range of differently configured power-tillers
2. to further modify and alter the existing standard Asian rotary hoe based full tillage power tiller seed drill to convert it to a true zero tillage/strip tillage unit that will operate in an extensive range of soil and environmental conditions.

Project Progress

First progress report due in 2008.

LWR/2005/001: Addressing constraints to pulses in cereals-based cropping systems, with particular reference to poverty alleviation in north-western Bangladesh

Bilateral

Overseas Collaborating Countries	Bangladesh
Commissioned Organisation	Murdoch University, Australia
Project Leader	Associate Professor Richard Bell Phone: 08 9360 2370, 08 9360 6000 Fax: 08 9310 4997 Email: rbell@murdoch.edu.au
Collaborating Institutions	Wheat Research Centre,Bangladesh Agricultural Research Institute, Bangladesh International Maize and Wheat Improvement Center, Bangladesh People's Research Oriented Voluntary Association, Bangladesh Rangpur Dinajpur Rural Service, Bangladesh Bangladesh Agricultural Research Council, Bangladesh Department of Agriculture and Food, Western Australia, Australia Department of Agricultural Extension, Bangladesh
Project Budget	$847,050
Project Duration	01/10/2006 to 30/09/2010
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

North-western Bangladesh, the poorest region of the country with regular food shortages and dietary imbalances, grows few pulse crops such as chickpea, lentil, mung bean and black gram. This is despite an apparently suitable climate and much fallow land charged with residual soil moisture after harvest of monsoon rice.

This project will institute a targeted program to increase the production of chickpea and lentils in the High Barind Tract (HBT) and two districts in the northern Rajshahi Division — to enhance income generation, improve human health and contribute to cropping system sustainability. Achieving this will involve addressing some major bottleneck constraints. These include socio-economic issues such as farmer-perceived 'risks' in relation to timeliness of crop planting, lack of farmer awareness of required and available technology, and scarcity of seed of improved varieties.

Major biophysical constraints are acid soil problems and poor seedling establishment due to inadequate seed and fertiliser placement techniques with existing tillage options. Some overlapping constraints also impact on the pulse industry in Australia and it is proposed that synergies could be gained by jointly addressing them.

Interactive partnerships across the research-to-adoption spectrum will enable resource-poor farmers to adopt existing and evolving technical information. Critical to the success of the project is that collaborating organisations work jointly with extension agencies, farmers and local business, and also carry out research predominantly in farmers' fields.

The principal aim of the project is to improve livelihoods of the rural population in NW Bangladesh through increased production of rabi (winter) pulses.

The project objectives are:

- to assemble, improve and disseminate packages describing best practices for chickpea cultivation to new areas in the HBT
- to expand cultivation of winter pulses into the northern Rajshahi Division as represented by Dinajpur and Thakurgaon Districts
- to develop, test and disseminate power tiller mounted drills for appropriate placement of seed of pulses and required fertiliser in the seedbed
- to assess the benefits of deep placement of fertilisers for pulse crops and their variation with soil, time of placement, row spacing and season.

Project Progress

Year 1 (01/10/2006–30/09/2007)

The 60 on-farm demonstrations conducted in the 2006–07 season confirmed that the existing chickpea technology is generally suitable for the central and northern parts of the High Barind Tract (HBT). Major biophysical constraints contributing to risk of chickpea cultivation in the HBT continue to be low and unpredictable soil moisture status and *Helicoverpa* pod borer attack. The market price is clearly very attractive, and farmers appreciate that costs of inputs are very low compared to boro rice, wheat or maize. The sub-sector mapping arising from the Business Development Services (BDS) workshop held in February will help to identify the key bottlenecks on which the Project should focus to more widespread adoption of chickpea in the HBT.

Generally, lentil cultivation under the project has been successful in northern Bangladesh, with yields exceeding the national average being achieved by the novice growers in most of the 120 demonstration plots sown. Plant populations established were mostly satisfactory except when sown into excessively wet soil, where nodulation was inhibited or delayed resulting in slow and/or uneven greening of the canopy. The other major constraint to lentil was *Stemphylium* blight but this could be managed by fungicidal spraying and minimising canopy density. It appears that there is a narrow range of optimum population density for lentil in this environment: this range will need to be established for PTOS-sown crops.

Although soils of the region are acid (pH 4.5–5.5), lentil appeared to grow satisfactorily in many plots. Poor growth could mainly be attributed to initial waterlogging events, which prevented or delayed N_2 fixation. However, in the on-farm trial at Tupamari, Nilphamari, there was a large lime response, even though growth in general was very poor at this location. Further experimentation is required to understand the nature of the lime response.

Many lentil fields had two weedings, but this had not controlled weeds sufficiently. Further attention to weed control will be needed for the moister conditions of northern Bangladesh, especially with PTOS-seeding in rows. BARI developed a dryland hand weeder (or 3-kata) that may be used for weeding in row-planted crops. Applying herbicide is one of the options for weed control. Typical B deficiency symptoms of lentil were observed in only a few of the fields seen. An uneven hand broadcasting of the B fertiliser may have resulted in the sporadic appearance of symptoms.

Novice farmers (50) in the northern Bangladesh also generally achieved yields of chickpea higher than the national average. An on-farm trial confirmed the need to apply boron, molybdenum and *Rhizobium*, but there was also an additional response to lime. Other major constraints to chickpea were botrytis grey mould, collar rot (*Sclerotium rolfsii*) and pod borer. Biophysical constraints to lentil and chickpea in the northern districts were prioritized in a project report and overall constraints to production and consumption of these crops in north-western Bangladesh will be analysed through a BDS approach.

After various modifications with the rotary tiller, the 4-blade strip tiller was found to be the best option for minimum tillage, row planting. Bent blades throw too much soil out of the strip, leaving an open slot to about 2–3 cm depth. Straight ‘C’ type blades work better. However, on the heavier soils such as the Barind soil the slot remains open to 2–4 cm, and makes it difficult for the press wheel to press the soil down on the seed. This may require laddering to drag soil back into the strip.

Chains behind the rotary tiller may be able to pull the soil back into the strip. Perhaps a different shape or thickness of the press wheel may be required. It would be desirable that further testing of some of these options occurs before the 2007 rabi season.

A 16 HP power tiller (PT) pulled two tynes through the medium textured HBT soils. However, very few 16 HP PT exist and hence the development of no-till planters should not be reliant upon 16 HP PT, but rather developed for 12 HP machines as these are cheap and commonly available.

The project organised a series of training programs on lentil and chickpea cultivation and followed up with field days aimed at disseminating optimum cultivation methods. The project held an inception workshop on 5 November 2006, a BDS workshop, on 4–5 February 2007 and a review workshop and coordination meeting on 24 May 2007. Two PhD scholars were identified to work on the project and arrangements made for a training visit of two Bangladeshi Project members to Australia in August–September, 2007. The Australian component of the project began in June 2007 with the sowing of a field trial examining interactions between row spacing, fertiliser placement, soil moisture and seed priming of chickpea at Merredin in Western Australia.

LWR/2005/146: Expanding the area for Rabi-season cropping in southern Bangladesh

Bilateral

Overseas Collaborating Countries	Bangladesh
Commissioned Organisation	CSIRO Sustainable Ecosystems, Australia
Project Leader	Dr Peter Carberry Phone: 07 46881377, mob 0419 656955 Fax: 07 46881193 Email: peter.carberry@csiro.au
Collaborating Institutions	International Maize and Wheat Improvement Center, Bangladesh Wheat Research Centre, Bangladesh Agricultural Research Institute, Bangladesh PROSHIKA, Bangladesh
Project Budget	$1,049,098
Project Duration	01/01/2007 to 30/06/2010
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

Farmers in southern Bangladesh currently depend primarily on one rice crop per year to provide income for their families from tiny farms (commonly less than 1 ha). Thus around 800,000 ha of agricultural land lie uncultivated in southern Bangladesh during the dry (*rabi*) season, primarily because irrigation resources are limited by the general unsuitability of the area for deep or shallow tube wells. Other constraints add to the perception that the area is too risky for wheat in a rice-wheat rotation - the area is hotter than the north, with a shorter potential season, and some of the soils are saline.

Sowing of wheat in the south is delayed well beyond the date considered optimal in the north because local wet season (*kharif*) rice varieties can be long duration. Also later drainage of monsoon waters delays the start of cultivation, a process which takes time with bullock-drawn ploughs.

Recently these southern lands have been reassessed for cultivation of wheat. Trials funded by FAO (2003–05) and ACIAR (2005–06) demonstrated how to shorten the time between rice harvest and wheat planting, using surface-stored water for limited irrigation. Three years of on-farm trials at five sites produced wheat yields exceeding 2.5 t/ha, even without irrigation in some locations.

Modelling in the ACIAR study, using historic local weather data and the **A**gricultural **P**roduction **S**ystems s**IM**ulator (APSIM), indicated that wheat, mungbean and maize can be grown with low-risk, long-term economic feasibility, particularly if surface flood water (stored over from the *kharif* season) is sufficient for one in-crop irrigation.

Specific objectives of this project are: to delineate and characterise the areas where *rabi*–season cropping is feasible on currently fallow lands, with or without supplementary irrigation; to tailor agronomic practices to suit each chosen region and socio-economic grouping, especially in the efficient utilisation of limited water resources and fertilisers (Bangladesh and Australia); to encourage farmer uptake of emergent cropping practices through training and support of the regional change agents committed to supporting Bangladeshi smallholder farmers.

Project Progress

First progress report due in 2008

CIM/2001/039: Integrated management of Botrytis Grey Mould of chickpea in Bangladesh and Australia

Multilateral

Overseas Collaborating Countries	Bangladesh
Commissioned Organisation	Centre for Legumes in Mediterranean Agriculture, Australia
Project Leader	Professor Kadambot H M Siddique Phone: 08 6488 7012 Fax: 08 6488 7354 Email: ksiddique@fnas.uwa.edu.au
Collaborating Institutions	International Crops Research Institute for the Semi Arid Tropics, India University of Melbourne, Australia NSW Department of Primary Industries, Australia Department of Primary Industries, Victoria, Australia Bangladesh Agricultural Research Institute, Bangladesh Department of Agriculture, Western Australia, Australia,
Project Budget	$907,280
Project Duration	01/07/2002 to 23/11/2006
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Pulse crops (food legumes) are the second most planted crops in Bangladesh after rice, reflecting the importance of pulses as a source of protein in Bangladeshi diets. The dominant pulse crops are lathyrus, lentil, chickpea, black gram and mungbean, and the Gangetic Plain in the country's west is the main area of pulse cropping. But cereals yield better, and pulse crops grown in similar conditions do not reach their potential.

Chickpea in particular is important, providing a high-level source of protein (21.7%) along with complex carbohydrates, dietary fibre, unsaturated fats and essential vitamins and minerals. Yet chickpea yields have fallen below expectation while demand remains at a constant high. Much excess demand is met from imports rather than domestic growth—between 1995 and 1999 FAO reported imports of chickpea rose by more than 50,000 tonnes.

The decline in chickpea production is due largely to a single factor—the foliar disease Botrytis Grey Mould (BGM). Epidemics of BGM have reduced yields, leading to shortfalls in seed supplies. The lack of control against BGM has eroded farmers' confidence in planting chickpea. In Australia similar outbreaks of BGM have the potential to become epidemics.

Known treatments—seed dressings and multiple fungicide applications — can control BGM but are too expensive for Bangladeshi farmers and unsustainable in Australia. Another form of control is needed, and an integrated disease management (IDM) approach offers the best strategy for both countries.

The project aimed to better manage outbreaks of BGM and thus increase yield of chickpea and stability of yield over seasons, by optimising its cultivation in traditional chickpea-growing areas of Bangladesh and focusing both in Bangladesh and Australia on the implementation of integrated disease management (IDM) strategies.

Project outcomes

Field screening to identify chickpea lines with resistance to BGM took place in Bangladesh over four seasons. Nearly 500 genotypes were screened in 2002–03, 208 in 2003–04, 200 in 2004–05 and 281 in 2005–06. From the second season onwards, entries comprised promising selections from the previous season and some new entries. Field screening was also carried out at the BGM-endemic site of Tarahara, Nepal, in 2002–03, but further screening was discontinued due to the security situation there.

There were clear differences in reaction to BGM, as measured on a 1 to 9 rating scale at each location in all seasons. Apart from the first season, there was a reasonable correlation (negative) between disease score and seed yield. Some lines with moderate levels of resistance were identified, with a consistent reaction across sites and seasons.

Screening for BGM resistance under controlled environment conditions proceeded from 2003–04. At ICRISAT in India, one-quarter of those screened were rated 'moderately resistant' but none as 'resistant'. The same set of entries was also screened for ascochyta blight resistance and 51 were rated as 'resistant'. There was no clear correlation between BGM resistance and ascochyta blight resistance, but nine lines were identified as relatively resistant to both diseases in both seasons.

In 2003–04 138 genotypes were screened for BGM resistance in a glasshouse at Horsham in Victoria, under a similar protocol to ICRISAT. Resistance ratings at Horsham were not consistent with assessment elsewhere, in field screening in Bangladesh or in the growth room at ICRISAT. Nevertheless, it was possible to identify eight lines with relatively greater resistance in both growth room and field.

Isolates of *Botrytis cinerea* were collected in Bangladesh, India, Nepal and Australia and subjected to PCR-based microsatellite DNA analysis. For the Bangladesh isolates, there was a high degree of variation within subpopulations and the total population, indicating a high adaptive potential of the fungus to chickpea. This suggests that multiple resistance genes and mechanisms will be required if durable resistance is to be achieved. Environmental conditions restricted sampling in Australia, thus the extent of genetic variability of the fungus in Australia, and the degree of similarity between Australian and Bangladesh populations, is not yet established.

A seed infection and germination test for assessing chickpea seed for infection with *Ascochyta rabiei* in Australia was also found suitable for *Botrytis cinerea*. This protocol was demonstrated to Bangladeshi scientists visiting Australia in 2005; it was later evaluated by staff at one of the BARI On-Farm Research Division offices prior to the 2005-06 growing season.

A series of on-farm trials was conducted in Bangladesh in order to evaluate various components of disease and crop management under farmers' conditions and merge them with the evolving integrated crop management (ICM) package for chickpea. On-farm variety evaluations were conducted to determine farmers' preferences for varietal characteristics, as a guide in developing future BGM-resistant varieties.

From the 2002–03 season ICM packages incorporating best-bet technologies for BGM management along with other optimum agronomic packages, were assembled and tested in farmer-managed operational scale plots (666 m^2) and compared with adjacent plots where prevailing farmers' practice was followed. Yield increases in five districts due to ICM were around 20–50%. The same degree of response to ICM was found from evaluations in 2003–04. In three additional districts the yield response was 30–60% increase. Follow-up demonstrations during 2004–05 resulted in district mean yields that exceeded 1 tonne per ha, making chickpea very competitive with other cropping options for the *Rabi* (winter) season.

LWR/2005/042: Scoping study to assess the technical and economic feasibility of wheat production in southern Bangladesh

Bilateral

Overseas Collaborating Countries	Bangladesh
Commissioned Organisation	CSIRO Sustainable Ecosystems, Australia
Project Leader	Dr Peter Carberry Phone: 07 46881377 Email: peter.carberry@csiro.au
Collaborating Institutions	International Maize and Wheat Improvement Center, Bangladesh Wheat Research Center, Bangladesh Agricultural Research Institute, Bangladesh
Project Budget	$114,500
Project Duration	01/10/2005 to 31/07/2006
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

Due to unavailability of shallow and deep tube wells, an estimated 800,000 ha of land in southern Bangladesh remains uncultivated during the dry (*rabi*) season. In the past, these lands were considered too risky for rice-wheat rotations because of the hot, short-season *rabi* environment and, in some districts, the saline soil profile and limited water resources.

Only recently have these southern lands been reconsidered for *rabi*-season production of crops such as wheat, maize and mungbean, using supplementary irrigation from limited surface water stored over from the wet *kharif* season.

Therefore, the aim of this study was to scope the long term technical and economic feasibility of wheat production on currently fallow lands in southern Bangladesh. It included a systems simulation analysis using the Australian-developed Agricultural Productions System sIMulator (APSIM) model.

Project outcomes

The project combined data from on-farm trials with system modelling to generate the production potential on crop lands for three representative districts in southern Bangladesh. Field crop-soil-climate datasets collected from three years of on-farm trials (two previously funded by FAO and one from the 2005-06 season funded as part of this project) were used to set up and test the APSIM systems model (www.apsim.info) for this production system.

Minimum datasets were also collated to quantitatively describe the long-term climate, soils, irrigation resources and management systems for current and proposed cropping systems in the region.

Utilising these data, the feasibility of rabi-season cropping systems was simulated using APSIM, incorporating 20 years of climate data (1985–2006) for the three regions: a traditional wheat production area (Jessore) and two new areas (Barisal, Noakhali) are being considered for cropping.

The three years of on-farm trials clearly demonstrated that irrigated wheat can be grown in these regions. Yields (3–4 t/ha) approximated those attained from more traditional wheat production areas. A key question was access to irrigation water. The scoping study suggested that much of the area has a significant amount of soil water stored as surface water or shallow water tables of high quality at the start of the rabi season.

This study provided justification for continued R&D investment in the production of rabi-season crops on currently fallow lands in southern Bangladesh. Specifically, the water resources of southern Bangladesh need to be characterised to determine their potential availability for irrigation in terms of surface and soil water, their distribution, and a record of the types of water bodies and their quality.

The impact of temporal and spatial salinity levels on wheat production and tolerance of current and improved varieties to salinity all require deeper consideration. Agronomic practices, especially in the timing and amounts of fertiliser and irrigation, need to be adapted to increase ecological sustainability, profitability and yield.

Finally, to achieve wider extension of agronomy recommendations tailored to each new cropping region, resources are needed to train regional extension officers and their farmer clients.

PART 4:
OTHER SOUTH ASIAN AND MIDDLE EAST COUNTRIES

14 Annual Report 2006-07

Active projects in 2006-07	9
AOP budgeted expenditure in 2006-07	$492,928
Actual expenditure in 2006-07	$528,434
Expenditure in 2005-06	$68,131
Expenditure in 2004-05	$436,885

Key performance indicators	Performance 2006-07
At least five Iraqi scientists receive in-depth training in integrated pest management (IPM)	Five Iraqi scientists trained by CSIRO and QLD Dept of Primary Industries and Fisheries for 5 months of intensive IPM.
CIMMYT wheat lines identified with improved yield and/or disease resistance to local lines in field trials in Afghanistan	Eighty-two promising bread wheat lines advanced based on both yield and disease resistance as evaluated in multi-site yield trials.

14.1 Bhutan

Position

ACIAR's small program with Bhutan began in 1998. Because of Australia's relatively low comparative advantage, the program has remained small. Earlier ACIAR research to develop Newcastle disease vaccine for village chickens was extended and adapted for the situation in Bhutan with the help of AusAID funding, and projects were initiated on the management of fruit flies, and on footrot management in ruminants. A major initiative on improvement of citrus protection and pest and disease management is under design.

Achievements

A new project aimed at improving mandarin production in Bhutan and Australia through the implementation of on-farm best management practices commenced in April 2007, as part of the Bhutanese Government initiative to substantially increase the country's production of citrus (mainly mandarin). This project seeks to lift overall productivity of Bhutan's citrus on a sustainable basis and to improve the quality and yield of its present mandarin cultivar.

A short-term scoping study commenced in May 2007. Its main purpose is to make recommendations to the Royal Government of Bhutan on possible actions for improved land and water management practices, specifically in relation to surface water and watershed protection, water harvesting, improved cropping/farming practices and improved water use efficiency.

14.2 Afghanistan

Position

Two decades of war coupled with a recent severe drought devastated Afghanistan's food-production capabilities and depleted critical seed stocks, leaving the nation heavily dependent on food aid from international donors.

ACIAR's multilateral projects in Afghanistan provide short to medium term support to wheat and maize production, wheat being by far the most important crop and maize the third most important. The objective of the project is being achieved principally through provision of seed of suitable cultivars via import, establishment of on-farm participatory testing of imported germplasm for the identification of better-adapted improved cultivars, and local multiplication and distribution of improved cultivars. Particular attention will be paid to improved yellow rust resistance in wheat and to promoting improved crop management along with improved cultivars of both wheat and maize. The capacity of local NGOs, state scientists and farmers will benefit. The project is co-funded by AusAID, managed by ACIAR and executed by CIMMYT.

Achievements

Despite the logistical difficulties and the difficult security situation in some parts of Afghanistan, the project 'Wheat and maize productivity improvement in Afghanistan' has progressed successfully. In collaboration with researchers in the Agricultural Research Institute of Afghanistan (ARIA), 126 promising wheat and maize varieties have been identified, six of which are potential candidates for official release nationally. Promising varieties, as well as appropriate crop management practices, are being demonstrated on-farm in collaboration with a strong network of NGOs and government partners.

There is strong anecdotal evidence that the varieties introduced by the project are being adopted. This is particularly evident in Alingar district in the Laghman province, where the project works in collaboration with farmers and the Norwegian Project Office, and where a double cropping of improved wheat and maize varieties introduced by the project is potentially beneficial to the farmers. Such a combination improves the productivity of wheat-based cropping systems and provides farmers with a viable option to replace poppy production. Finally, the project has made good progress towards developing a strong core team of well trained national scientists working in the public, private and NGO sectors.

Afghanistan is also involved in the ACIAR-supported activities at CIMMYT, ICARDA and PBIC-Sydney University to ensure productivity and food security through **sustainable control of wheat yellow rust** in Asia.

14.3 Nepal

Position

Almost 85 per cent of Nepal's population of 24 million are rural and the majority of these are involved in agriculture. ACIAR formerly had a small program of projects in Nepal, with an emphasis on the lowland Terai, which has more in common with Australian agricultural production environments than upland areas.

The discipline focus for collaboration has emphasised crop production and management, and some aspects of animal health. ACIAR-funded research has made progress in the fields of crop and livestock health and productivity and land management.

Benefits to date include the development of a specific vaccine which has effectively targeted the two strains of virulent footrot existing in Nepalese sheep and goats, the introduction of new varieties of lentils resistant to disease and drought, and the identification of factors in wheat sterility (low temperature and boron limitations). However, ACIAR is no longer developing any new projects with Nepal.

Achievements

Scientists have continued investigation of fungal wilt and Stemphyllium (a damaging leaf and stem disease) in lentil, seeking to identify tolerant lines for use as genotypes for direct release or as parents in breeding programs in Nepal and Australia. They have also investigated the efficacy of seed priming for improving seedling establishment, vigour and yield in lentil post-rice ('paira') cropping systems in Nepal. The technology is being extended to farmers though on farm demonstrations and seed increase of promising genotypes. The project has advanced the development of new Lathyrus germplasm with low toxin to make it more suitable as food for humans and livestock in Nepalese conditions, giving new impetus for inclusion of this crop in farming systems there.

14.4 Iraq

Position

The high levels of input subsidies, guaranteed commodity prices and free food distribution have distorted agricultural markets in Iraq and have provided no incentive for innovation by farmers. In addition, scientists have had limited access to international developments in the agricultural sector for over two decades. In concert with other investments by AusAID, the ACIAR projects are intended to assist the Iraqi Government in its quest to modernise agricultural markets and production systems.

The projects have been shaped by the relevance of Australian expertise to Iraqi conditions and by the constraint of limited access to Iraq by Australian scientists. One project will focus on the enhancement of barley, wheat and grain legume production under dryland conditions in northern Iraq through the introduction and evaluation of appropriate modern varieties, coupled with the adaptation of improved management practices, including tillage, fertiliser and weed control.

Significant yield improvements are anticipated, given that current yields of these crops are only about one-third that under similar conditions in developed countries. In the second project Australian scientists will initially assist Iraqi senior scientists to develop a National Strategy Plan for the control of jasmine whitefly affecting citrus production in central Iraq, and follow this with training in Australia of junior scientists in integrated pest management practices to enable them to implement that Plan upon return to Iraq. The projects are co-funded by AusAID and ACIAR, managed by ACIAR and executed by ICARDA and Australian research organisations.

Achievements

The jasmine white fly project has concluded. As recorded in last year's annual report, a strategic plan for the management of jasmine fly and also the dubas bug in the date palm/citrus complex of central Iraq has been submitted to the Iraqi government and formally accepted.

How to act on the plan will require considerable further discussion, planning and development. Five Iraqi scientists have spent time in Australia, three located with Queensland Department of Primary Industries & Fisheries to work on active integrated pest management projects, while a further two were located at CSIRO Entomology in Brisbane working as part of the silverleaf whitefly biocontrol program.

Another project has sought to develop better crop germplasm and management for improved production of wheat, barley and pulse and forage legumes in Iraq. Despite many difficulties, the project has gone remarkably well, facilitated by the enthusiasm, flexibility and dedication of Iraqi collaborators, the proximity of ICARDA in Syria, and the interest and support of ICARDA and Australian scientists.

An agreed workplan for the demonstration program has been carried out as planned at 13 locations in the four main agroclimatic zones. However, heavy rain, security concerns, land disputes and transport shortages have reduced from 80 down to 30 the planned research trials evaluating better adapted lines/varieties.

On-farm demonstrations of improved varieties were conducted as planned in the following types of location: three high-rainfall areas; four medium-rainfall areas; three low-rainfall areas; three with supplementary irrigation. Best-bet technologies and new lines/varieties were tested and demonstrated with farmers in a participatory manner at these sites.

In project-linked research at ICARDA, a range of varieties/lines of oats, peas, canola and other oilseeds from Australian collaborators was introduced and tested for adaptation and use in Iraq. Some varieties grew and seeded very well. The trial was inspected and discussed with several groups of visiting Iraqi scientists, and seed from material of interest in Iraq and ICARDA was collected for broader testing.

The project has re-established international linkages amongst Iraqi, ICARDA and Australian scientists. Twenty-six Iraqi scientists have participated in six ICARDA training courses, and there were several visits by others to discuss and plan project activities. Australian collaborators have presented four seminars of relevance to Iraq, covering advances in cereal and legume improvement, crop management and crop-livestock interactions in Australia.

15 Annual Operational Plan 2007-08

Population	58.8 m
Population 2015	80.6 m
Active bilateral projects	3
Active multilateral projects	4

Bilateral actual 2005–06	$0.07 m
Bilateral estimate 2006–07*	$0.49 m
Bilateral budget 2007–08	$0.21 m
Bilateral + multilateral budget 2007–08	$0.54 m

***Includes AusAID funding of projects in Iraq and Afghanistan ($0.33 m) (estimate 2006–07)**

15.1 Key performance indicators (2007–08)

- New project activities initiated in Bhutan supporting the key agricultural export product, citrus
- 'Best bet' varieties of a range of suitable crops and technologies identified and being tested in dryland farming areas of northern Iraq
- Dissemination of promising wheat and maize varieties and further training of Afghan scientists and NGOs

15.2 Medium-term strategy and priorities

ACIAR is managing one project in Iraq, co-funded by AusAID. It is anticipated that support will be limited to this project in the short- to medium-term as Iraq passes through a critical period of development. Some activity will continue in Afghanistan through collaboration with CGIAR centres. ACIAR provides both core and project-specific funds to ICARDA (International Centre for Agricultural Research in the Dry Areas, headquartered in Syria).

These projects benefit ACIAR partner countries in Asia as well as Australia and developing countries in the Middle East and former Soviet Republics. Three multilateral projects involving ICARDA are currently active, and ICARDA is also a key partner in the ACIAR-supported project in Iraq. In Bhutan, there is one active, major project and any additional projects would need to be initiated and strongly endorsed at an early stage by the Bhutan Government and closely fit Australia's skills and expertise.

ACIAR has no formal program of consultations on priorities with these countries. Priorities are developed through visits by research program managers and other senior staff, meeting with leading agricultural R&D institutions and government bodies.

Bhutan

ACIAR's small program with Bhutan began in 1998. Because of Bhutan's relative lack of capacity to effect significant change across many agricultural sectors at once, the program will remain small and very tightly focused. Earlier ACIAR research to develop Newcastle disease vaccine for village chickens was extended and adapted for the situation in Bhutan with the help of AusAID funding, and projects were initiated on the management of fruit flies, and on footrot management in ruminants. A major initiative on improvement of citrus production (Bhutan's largest horticultural export industry) and pest and disease management is being implemented, as well as a smaller study on water and land management.

Afghanistan

Two decades of war coupled with a recent severe drought devastated Afghanistan's food-production capabilities and depleted critical seed stocks, leaving the nation heavily dependent on food aid from international donors.

ACIAR's multilateral project in Afghanistan provides support to wheat and maize production. Wheat is by far the most important crop while maize is the third most important. Capacity enhancement is also very important. Activities have been aimed principally at provision of seed from suitable cultivars via import, establishment of on-farm participatory testing of imported germplasm for the identification of better adapted improved cultivars, and local multiplication and distribution of improved cultivars. Particular attention is being paid to improved rust resistance in wheat and to promoting improved crop management along with improved cultivars of both wheat and maize.

Iraq

The high levels of input subsidies, guaranteed commodity prices and free food distribution have distorted agricultural markets in Iraq and have provided no incentive for innovation by farmers. In addition, scientists have had limited access to international developments in the agricultural sector for over two decades. In concert with other investments by AusAID, the ACIAR project is intended to assist the Iraqi Government in its quest to modernise agricultural markets and production systems.

The project has been shaped by the relevance of Australian expertise to Iraqi conditions and by the constraint of limited access to Iraq by Australian scientists. It is focused on the enhancement of barley, wheat and grain legume production under dryland conditions in northern Iraq through the introduction and evaluation of appropriate modern varieties, coupled with the adaptation of improved management practices, including tillage, fertiliser and weed control techniques.

Significant yield improvements are anticipated, given that current yields of these crops are only about one-third that under similar conditions in developed countries. The project is co-funded by AusAID and ACIAR, managed by ACIAR and executed by ICARDA and Australian research organisations.

16 Projects (summary and progress reports)

16.1 Subprogram 1: Field crop germplasm improvement and utilisation

Active

CIM/1999/064	Lentil and Lathyrus in the cropping systems of Nepal: improving crop establishment and yield of relay and post-rice-sown pulses in the terai and mid-hills
CIM/2003/067	Ensuring productivity and food security through sustainable control of yellow rust of wheat in Asia
CIM/2004/024	Better crop germplasm and management for improved production of wheat, barley and pulse and forage legumes in Iraq

Concluded

CIM/2004/002	Wheat and maize productivity improvement in Afghanistan

Pipeline

CIM/2007/065	Sustainable wheat and maize production in Afghanistan

CIM/1999/064: Lentil and Lathyrus in the cropping systems of Nepal: improving crop establishment and yield of relay and post-rice-sown pulses in the terai and mid-hills

Bilateral

Overseas Collaborating Countries	Nepal
Commissioned Organisation	University of Western Australia, Australia
Project Leader	Dr Clive Francis Phone: 08 6488 1878 Fax: 08 9380 1140 Email: cfrancis@cyllene.uwa.edu.au
Collaborating Institutions	Agriculture Victoria, Australia Birchip Cropping Group, Australia Centre for Legumes in Mediterranean Agriculture, Australia Nepal Agricultural Research Council, Nepal International Center for Agricultural Research in the Dry Areas, Syria
Project Budget	$634,422
Project Duration	01/07/2001 to 31/12/2007 (Project extended from 01/07/2004 to 31/12/2007)
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Nepal has increased production and export of pulses by about 44 per cent in the last 15 years. Regional prices are variable, but can be very high. Within the country, lentils are an important and valuable crop for human consumption (mainly consumed as dhal). The grain contains about 28 per cent crude protein. Lentil straw is rich in nitrogen and is a palatable livestock feed. Lentils are mainly grown on the lower, flatter part of the country and in the gentler hills up to about 2000 metres elevation. The main constraints on Nepal's lentil production are fungal disease and low yields caused by dry soil. This last problem is a consequence of late planting of the crop after the rice harvest. In addition, lentils are often cultivated on marginal land and with poor management practices. The plant is also very sensitive to low pH; soil in some of the lentil-growing regions is becoming increasingly acidic and so reducing yields further.

An earlier ACIAR project worked on improving drought resistance and disease resistance in lentils. This project continues the work to improve the yield and quality of lentils produced in marginal and drought-prone environments (in Australia as well as Nepal) by identifying genotypes with higher yields, and by using selective breeding to improve the tolerance of the plant to acid soils and common diseases.

Australia's small but developing lentil industry would also benefit from drought-tolerant genotypes. In addition, the scientists are working on *Lathyrus sativus* (the grasspea) which contains a toxin that can cause a neurological condition known as lathyrism. A reduction in the amount of toxin produced would make this plant more suitable for use as an animal feedstuff and also protect people who, through desperation or unscrupulous traders, eat foodstuffs containing this product.

Project Progress

Year 5 (01/07/2006–2006–30/06/2007)

Annual report not yet submitted by the Commissioned Organisation.

CIM/2003/067: Ensuring productivity and food security through sustainable control of yellow rust of wheat in Asia

Multilateral

Overseas Collaborating Countries	Afghanistan, Bangladesh, China, India, Pakistan
Commissioned Organisation	International Maize and Wheat Improvement Center, Mexico
Project Leader	Dr Ravi Singh Phone: 52 55 58042004 Fax: 52 55 58047558 Email: r.singh@cgiar.org
Collaborating Institutions	University of Sydney, Australia International Center for Agricultural Research in the Dry Areas, Syria Global Overseas Collaborators, Global
Project Budget	$1,000,050
Project Duration	01/01/2005 to 31/12/2009
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Wheat is a widely grown crop throughout many parts of Asia. Of the total worldwide areas planted to wheat more than 40 per cent is grown in Asia where it is an important staple food crop. Of the 95 million hectares devoted to wheat cropping almost half this area (some 43 million hectares) is susceptible to stripe rust.

Stripe rust's causal agent, *Puccinia striiformis tritici (Pst)*, can spread rapidly. It is capable of air-borne migration being carried long distances by wind. The agent can also evolve rapidly into new wheat races (those of a common ancestry). Growing numbers of wheat races have proven susceptible to yellow rust. Once wheat resistant gene, *Yr9*, present in several wheat races, in South, West and Central Asian countries has begun to break down, resulting in millions of dollars of losses from rust.

Current control measures, fungicides applied at the appropriate time in the cropping cycle, are adequate. These have, however, environmental and price constraints, causing pollution and adding to production costs. Growing new varieties with rust resistance is likely to produce the most successful control option, also addressing cost and environmental constraints.

The ability of rust to travel distances, invade new races and break down resistant genes will require the identification and breeding of lines with a new genetic basis for resistance, the subject of this work.

The aim of this project is to increase the food security and profitability of wheat production systems in several countries of Asia and to protect the environment and human health through strategies contributing to the sustainable control of yellow rust disease of wheat.

Project Progress

Year 2 (01/01/2006-31/12/2006)

ACIAR funding supports ongoing and new research and capacity building activities at CIMMYT, ICARDA, and PBIC-Sydney University to ensure productivity and food security through sustainable control of wheat yellow rust, caused by *Puccinia striiformis tritici (Pst)*, in Asia. Development of new near-isogenic lines (NIL) for greenhouse and field monitoring for genes Yr2, Yr3, Yr4, Yr33, Yr34, Yr35, Yr36 is progressing to fill the gaps in the existing NIL set. NIL for gene Yr8 purified and multiplied and for Yr17 purified.

Specific gene combinations are also under progress. Data from Yellow Rust Trap nurseries planted at key sites in South Asia, China and CWANA regions indicate significant variations in Pst populations in these areas. Virulence for Yr17, first detected in Central Asia, is now widely spread.

Increasing virulence for Yr3 and its distribution in Pakistan and Afghanistan is a threat to the variety 'Tatara' the sown area of which has increased recently after the epidemic on 'Inquilab 91' during 2005. Lack of virulence for some genes that were ineffective previously is a major concern to progress in yellow rust breeding. A unified Yellow Rust Trap Nursery will now be planted in all countries except China which forms a different epidemiologic region with very different cultivars.

Several facultative/winter wheat cultivars grown, or newly released, in various countries of the CWANA region indicated that only a few were resistant at all sites except in Pakistan. This further demonstrated their vulnerability to diverse pathotypes predominant in different areas. Seedling gene postulation work on Central Asian cultivars conducted in Australia identified some of the commonly occurring genes, which have little or no value to provide resistance to some of the races known to occur in the region. Evaluation in Mexico of individual F2 derived-F5 lines from crosses of yellow rust susceptible Avocet with four Chinese cultivars that show moderate levels of resistance in China but immunity in Mexico confirmed F3 results that each cultivar carried 1 major gene and 2–3 minor genes.

Significant progress was made in incorporating durable resistance into several cultivars from China. Because these Chinese cultivars are highly resistant in Mexico but either susceptible or moderately resistant in China, we used a shuttle breeding strategy to speed up the breeding as well as select under high yellow rust pressure in China. During 2006 we identified 119 advanced lines with yellow rust resistance and desirable agronomic traits and planted them in replicated yield trials in farmers' fields during the 2006–07 season. Selections were done on 62 new BC1-derived-F5 populations involving 13 additional Chinese cultivars from Sichuan and Yunnan provinces during 2006 in Chengdu and over 1000 advanced lines were planted for further evaluation and selection during 2006–07. An additional 94 F4 populations were planted in Chengdu and Kunming following selection in the F2 and F3 generations in Mexico.

The '1st Elite Bread Wheat Yield Trial', containing 28 high-yielding entries with resistance to rusts, was grown at a total of 16 sites in India, Pakistan, Afghanistan, Iran and Turkey to find replacements for cultivars that are now susceptible to new races of yellow rust. Several new lines showed significantly higher yield potential and resistance at most of the sites in each country and were selected by the co-operators for further testing. Seed of high yielding entries for the '2nd Elite Bread Wheat Yield Trial' was multiplied during 2006 and planted at 30 sites in 11 countries. About half of the entries have shown high to moderate levels of resistance to the Ug99 race of stem rust pathogen.

Incorporation of yellow rust resistance in 21 facultative/winter wheat cultivars from Central Asian countries has been progressing well in Mexico. Populations in various generations from F1 to F3 were planted for either backcrossing or selection under yellow rust pressure in the 2006-2007 winter season at Toluca, Mexico.

A training course was organised in Uzbekistan for 20 scientists, mostly from Central Asia, to enhance their capacity in managing rust diseases of wheat and breeding for resistance. A Chinese scientist, Mr. Huazhong Zhu, attended a 3-month advanced training course on wheat improvement in Mexico. R.P. Singh, C. Wellings and A. Yahyaoui interacted with various scientists during visits to various breeding and pathology programs in China and Central Asia.

CIM/2004/024: Better crop germplasm and management for improved production of wheat, barley and pulse and forage legumes in Iraq

Multilateral

Overseas Collaborating Countries	Iraq
Commissioned Organisation	International Center for Agricultural Research in the Dry Areas, Syria
Project Leader	Dr Mustapha Pala Phone: +963212213433 Fax: +963212212490
Collaborating Institutions	Department of Agriculture, Western Australia, Australia Centre for Legumes in Mediterranean Agriculture, Australia University of Adelaide, Australia Ministry of Agriculture, Iraq
Project Budget	$1,200,680
Project Duration	01/05/2005 to 30/06/2008
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Agricultural production in Iraq employs around 20 per cent of the total workforce and provides an estimated eight per cent of GDP. In northern Iraq rainfed cereal cropping is a dominant industry, undertaken in conditions similar to those found throughout Australia's cropping zones. Low rainfall necessitates seed varieties well suited to the dry climate, and tolerant or resistant to salinity, drought and diseases.

Seed of commonly grown varieties was sourced from local stocks and from the International Center for Agricultural Research in the Dry Areas (ICARDA), based in neighbouring Syria, during the mid 1980s. These varieties and associated crop management practices have changed little since that time, having not benefited from research improvements over the past two decades. Only recently have pulse and legume varieties, which can help regenerate soils when cropped between wheat, barley and other cereals, been released.

Varieties of cereals resistant to drought, salinity and diseases are needed. Nineveh is the leading crop producing Governate in northern Iraq. ICARDA has an extensive collection of suitable germplasm possessing disease and stress tolerance and resistance characteristics to match cropping conditions found in this, and neighbouring, Governates. Identifying and disseminating suitable varieties could double production. Testing in Nineveh is identifying agronomic and crop management practices to support the growth of these crops throughout the northern cropping region.

The project is:

- identifying, promoting and disseminating amongst farmers in northern Iraq's rainfed cropping regions 'best-bet' improved varieties and crop management systems for wheat, barley, pulse and forage legumes
- introducing, evaluating and selecting improved germplasm for adaptation to rainfed farming systems in northern Iraq.

Project Progress

Year 2 (1/05/2006–30/04/2007)

Similar to the year of 2005–06 the implementation of the project has been difficult given the political and security situation in Iraq. There has been severe violence and bombings in Mosul and Tel Afar, where much of the project activity is located, which has made it difficult and dangerous for project personnel in both the office and field – these problems have escalated considerably since the start of the project.
Another constraint is that in-country field visits by ICARDA and Australian collaborators for planning, implementing and checking the work are not possible.

Despite these difficulties, the project has gone remarkably well since 1 July 2006. This has been facilitated by the enthusiasm, flexibility and dedication of Iraqi collaborators, the proximity of ICARDA, and the interest and support of ICARDA and Australian scientists.

There was a major reporting and planning meeting at ICARDA in October 2006, which was well attended by Baghdad, Mosul, ICARDA and Australian scientists. Using the experience of 2005–06, more manageable and realistic workplans were developed for cereal evaluation, legume evaluation, agronomy, socio-economic, and seed production R & D for 2006–07.

The Ninevah Implementation Committee, set up by MOA to manage the project, which functioned excellently in 2005-06, has been unable to meet regularly in Mosul/Ninevah as it is too dangerous, so coordination and oversight has been through regular visits and interactions at research and demonstration sites. The agreed workplans for the demonstration and research programs were carried out at 12 locations, 3 in each the four main agroclimatic zones, with a target of 41 demonstrations (33 for cereals and 8 for legumes) and 22 research yield trials (15 for cereals and 7 for legumes).

Some 60–70% of the demonstration workplan has been implemented with all crops sown in most of the 12 demonstration locations under farmer, improved tillage, and zero-tillage treatments. There is great enthusiasm about the potential of zero-tillage, which reportedly has never been tried before in Iraq. Enthusiasm has no doubt been increased by the increase in the price of 200 l of diesel from $2 a few years ago, to $125 in 2006, and to $250 in 2007 (near world prices). The two sub-soilers (deep tillage machines) requested by the DOA Ninevah group for trials and demonstrations have been purchased and dispatched, arriving a little late for 2006–07 planting but ready for 2007–08. There has been considerable interaction in the arrangements for purchase of 10 MOA-requested seed cleaning plants. A final inspection and specification check by MOA at the manufacturer's factory in Syria is pending. It is hoped the seed cleaners will be in place for use in seed cleaning after the 2007 harvest.

The agreed training program at ICARDA for about 20 Iraqi scientists was exceeded and a total of 34 participants took part in short-term courses and on-the-job training. In addition, eight farmers accompanied by four DOA Ninevah scientists including the Iraqi Project Manager, visited ICARDA and inspected research on soil and crop management and crop improvement including zero-till direct sowing compared with conventional deep tillage.

Activities were initiated and facilitated through two major meetings to identify 'best-bet' varieties and technologies for demonstrations and varieties/lines and technologies for further research. These meetings were held at ICARDA in October 2006 with ICARDA, Iraqi and Australian scientists and in Amman, Jordan, in January 2007 with project coordinators both from ICARDA and Iraq during the Iraq/ICARDA coordination meeting. Much of the discussion was based on previous experiences by collaborators in Iraq and in similar environments in north-east Syria.

Cereal and legume varieties and technologies of interest including zero-till direct sowing identified in these meetings were incorporated into a detailed 2006–07 workplan prepared at the October 2006 meeting, which formed the basis of trials and demonstrations undertaken in 2006–07. ICARDA and Australia provided additional seed for trials and demonstrations based on these evaluations and workplan.

On-farm demonstrations of improved cereal and legume varieties were conducted as planned in the following locations:

- High Rainfall Areas: Al Shekhan, Rabiah, Al Kosh
- Medium Rainfall Areas: Al Hamdaniah, Tel Keyf, Basheeka
- Low Rainfall Areas: Tel Abta, Al Hatra, Al Mahlabiah
- Supplementary Irrigation: Rabiah, Al Namroud, Humeydat

Similar to the 2005–06 season, best-bet technologies and new lines/varieties were tested and demonstrated at these sites in a participatory manner with farmers. Thus, crop varieties in demonstrations were planted under three crop management practices (zero-tillage, chisel plough soil preparation, farmers' practice). Experiences and findings were promoted widely amongst farmers through field days at each of the demonstration sites. Many farmers were interested in some of the improved varieties which seemed to perform better than farmer varieties. Dissemination will be encouraged further through distribution of seed from the demonstrations/trials to interested farmers for planting in 2007–08.

In the research program, a range of nurseries and trials were planted in late Dec/early Jan and these established well because of good January rains (>31 mm during late January) in Rasheedya Experimental Station in Mosul.

These were:

1. Barley Nursery for Iraq
2. International Barley Yield Trial–Moderate Rainfall Areas 2006–07 (IBYT07– MRA set 25)
3. International Barley Observation Nursery Moderate Rainfall Areas 2006–07 (IBON-MRA)
4. Chickpea International Elite Nursery-Latin America 2007 (CIEN-LA-2007)
5. Chickpea International Elite Nursery-Winter-2007 (CIEN–W–2007)
6. Faba Bean S1 populations 2007
7. Selection from Lentil F3 populations 2007
8. Comparison of 16 genotypes of 'Bekia' (*Vicia sativa*)
9. Effect of land management and crop rotation with Lentil on Durum Wheat Om-Rabi5 productivity and quality

New seed from ICARDA for trials and demonstrations was discussed and agreed at the Reporting/Planning meeting at ICARDA in October 2006. This supplemented the considerable amount of seed saved from the 2006 harvest in Ninevah. About 2 tonnes of seed was prepared and tested for pests/diseases – some seed was found to be contaminated and was replaced and retested. Testing was finished and the shipment was received by DOA Ninevah on 16 December. This did not delay the planting program which proceeded with seed already on hand following good rains in early November.

In project-linked research at ICARDA, four agronomy trials linked to the project on zero-tillage of oats, wheat, chickpea, and barley and adaptation/seed increase of Australian-supplied oilseeds and oats were established using the Indian zero-till planter at ICARDA in November 2006. These gave good information on new systems of conservation cropping and were useful for training of Iraqi visitors.

Some on-farm demonstrations of growing crops with zero-tillage and stubble mulching were also established on farms around ICARDA with the Indian zero-till seeder and local cooperating farmers seem very interested – encouragingly, the machine has worked very well, even on somewhat stony soils.

A range of varieties/lines of oats from Australian collaborators tested in 2005–06 season for adaptation and use in Iraq were planted for seed increase in 2006–07. Mitika and Possum out-yielded the others including local in a dry year with about 315 mm of seasonal rainfall. The trials were inspected and discussed with several groups of visiting Iraqi scientists and farmers.

Demonstrations and trials have been harvested and measured and data collected are now undergoing analysis and evaluation. Reports are being prepared and will be presented at the September 2007 annual reporting/planning meeting at ICARDA.

The project has again re-established international linkages amongst Iraqi, ICARDA and Australian scientists. Formal interactions at ICARDA included 34 Iraqi scientists participating in seven ICARDA training courses, eight farmers visiting accompanied by four Iraqi scientists to view conservation cropping and crop improvement research, and several MOA/DOA scientist groups visiting to discuss and plan project activities.

Australian collaborators presented four seminars in the October 2006 planning meeting on advances of relevance to Iraq on genotype-environment studies in chickpea and improved crop agronomy and management for more productive and sustainable dryland cropping in Mediterranean environments.

CIM/2004/002: Wheat and maize productivity improvement in Afghanistan

Multilateral

Overseas Collaborating Countries	Afghanistan
Commissioned Organisation	International Maize and Wheat Improvement Center, Turkey
Project Leader	Dr Hans-Joachim Braun Phone: 90 312 2873595 Fax: 90 312 2878955 Email: h.j.braun@cgiar.org
Collaborating Institutions	International Maize and Wheat Improvement Center, Afghanistan
Project Budget	$1,093,945
Project Duration	01/07/2004 to 30/06/2007
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Afghanistan is unable to produce sufficient wheat and maize to achieve self-sufficiency in its most important and third most important cereal crops. Two decades of conflict have eroded the country's wheat and maize cropping industries. During this time international advances in agriculture largely bypassed Afghan farmers, particularly smallholders. The main constraints to increased production are:

- lack of improved, well adapted varieties
- poor availability of quality seed
- lack of quality inputs, such as fertiliser
- inadequate production technologies and agronomic practices
- damaged irrigation, road and market infrastructure.

International efforts over the past two years have addressed many of these issues. ACIAR has been involved, managing an AusAID funded, International Maize and Wheat Improvement Centre (CIMMYT) implemented project addressing varietal improvements of wheat and maize.

This project is building on work to date by identifying promising new wheat and maize lines through testing of introduced germplasm. Appropriate germplasm (ranging from segregating populations to advanced lines and varieties) is available from CIMMYT, and from the region (e.g. Iran, Pakistan, Tajikistan and India).

Production and dissemination of sufficient high quality breeder seed of current and new varieties of wheat and maize is being undertaken. Breeder seed production remains the responsibility of Ministry of Agriculture and Animal Health (MAAH), while NGOs and farmers are playing a role in multiplying up seed so as to give numerous farmers access to quality seed of known improved varieties. Adaptation of improved management practices for wheat and maize, including the new varieties, under local conditions, is also underway.

Project Outcomes

Final report not yet submitted by the Commissioned Organisation.

16.2 Subprogram 2: Horticulture, including pest and disease management

Projects:

Active

HORT/2005/142	Improving mandarin production in Bhutan and Australia through the implementation of on-farm best management practices

Concluded

HORT/1997/094	Management of postharvest diseases of sub-tropical and tropical fruit using their natural resistance mechanisms
LWR/2007/212	Opportunities to improve land and water management in Bhutan

HORT/2005/142: Improving mandarin production in Bhutan and Australia through the implementation of on-farm best management practices

Bilateral

Overseas Collaborating Countries	Bhutan
Commissioned Organisation	NSW Department of Primary Industries, Australia
Project Leader	Ms Sandra Hardy Phone: 02 43481916 Fax: 02 43481910 Email: sandra.hardy@dpi.nsw.gov.au
Collaborating Institutions	Department of Agriculture, Horticulture Division, Bhutan
Project Budget	$765,647
Project Duration	01/04/2007 to 31/03/2011
ACIAR Research Program Manager	Mr Les Baxter

Project background and objectives

The current annual production of citrus (mainly mandarin) in Bhutan is 36,000 tonnes, of which 66% is exported – predominantly to India but also to Bangladesh. The Bhutanese Government has set a production target of 100,000 tonnes for export to be attained within the next 5 years. But there has been no real policy or strategy formulated to obtain this outcome.

ACIAR funded a Scoping Study to help develop this project. The study team found that marketable crop yields are low (7 tonnes per ha in Bhutan versus 30 tonnes per ha in Australia), due to poor orchard management and lack of control of Chinese fruit fly and the psyllid vector of citrus greening disease. The impact of citrus greening disease on orchard productivity and the extent of the disease in citrus orchards had not been fully evaluated or documented. The use of seedling trees when orchards are replaced or expanded also further delayed fruit production.

This project addresses overall productivity of citrus on a sustainable basis and seeks to improve the quality and yield of Bhutan's present mandarin cultivar. In Australia the ACIAR project will expand work already under way on mandarin rootstock/scion compatibility, tree and crop management strategies, assessment of fruit quality characteristics and marketing opportunities.

The specific objectives of the project are:

- to develop a commercial nursery production system which can provide high-quality planting material
- to implement a sustainable pest management program to control Chinese citrus fruit fly and the psyllid vector that transmits citrus greening disease
- to develop and demonstrate improved management practices such as the use of certified seedlings budded onto improved rootstocks, tree training and pruning, control strategies for the major pests/diseases, basic tree nutrition, irrigation and crop management principles
- to build the capacity of Bhutanese research and extension staff, by demonstration and training in commercial citrus production practices.

Project Progress

First progress report due in 2008.

HORT/1997/094: Management of postharvest diseases of sub-tropical and tropical fruit using their natural resistance mechanisms

Bilateral

Overseas Collaborating Countries	Philippines, Sri Lanka
Commissioned Organisation	Queensland Department of Primary Industries and Fisheries, Queensland Horticulture Institute, Australia
Project Leader	Dr Lindy Coates Phone: 07 3896 9468 Email: lindy.coates@dpi.qld.gov.au
Collaborating Institutions	Department of Agriculture, Sri Lanka University of Peradeniya, Sri Lanka Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, Philippines University of the Philippines at Los Banos, Philippines
Project Budget	$991,912
Project Duration	01/07/2002 to 30/06/2007 (Project extended from 01/01/2006 to 30/06/2007)
ACIAR Research Program Manager	Mr Les Baxter

Project background and objectives

Sri Lanka, the Philippines and Australia are significant producers of tropical fruit with good prospects for market development. However with current control measures, field and postharvest disease losses can hamper productivity and hamper market access. The shelf-life of most tropical and subtropical fruit crops is limited by their high susceptibility to postharvest diseases caused by *Colletotrichum* spp. (anthracnose), *Lasiodiplodia theobromae* and anamorphs of *Botryosphaeria* spp. (stem-end rot), with losses of 20 per cent common.

In mango, anthracnose also blights flowers and can cause complete crop loss before harvest, particularly if rain occurs at flowering. Field application of fungicides (e.g. copper compounds, mancozeb), and postharvest treatment with hot water and fungicides, currently form the basis for control of these pathogens, however due to the inadequacy of current options for field and postharvest disease control, alternative strategies need to be developed.

In developing disease management strategies for fruit, little attention has been given to the fact that plants have evolved powerful defence mechanisms to limit and prevent disease on developing fruit. These include biochemical (e.g. pathogenesis-related proteins, phytoalexins) and physical (e.g. lignification) barriers to pathogen invasion, and may be constitutive (preformed) or inducible in nature.

The chemical defences, involving preformed or induced chemicals, cause infections to remain localised and quiescent (with colonization restricted). As climacteric fruit ripen, the defence mechanisms begin to break down (antifungal compound levels drop) and disease begins to develop. Some cultivars have naturally higher levels of the constitutive antifungals (for example the cultivar Hass avocado) and so disease development in ripening fruit is delayed, allowing more fruit to be marketed and consumed before disease develops.

Furthermore, constitutive mechanisms may be up-regulated (induced) by a range of elicitors, to enhance host defences (and delay disease development). This project is exploiting those mechanisms to define new options for disease control.

The project is improving control options for field and postharvest diseases of tropical fruit to reduce reliance on current controls, which do not reliably ensure longer storage of fruit during retail marketing and export.

Project outcomes

Tropical and subtropical fruit crops are particularly susceptible to deterioration by postharvest disease, and significant losses are incurred in all production areas. Current control measures rely heavily on the use of fungicides, both before and after harvest. However, for many reasons we can expect that the use of these fungicides will become increasingly limiting. It is thus imperative that alternative or complementary strategies are sought.

The project was undertaken to evaluate the prospect of utilising inherent plant defence mechanisms in the management of postharvest diseases focusing on mango (Australia, Sri Lanka and The Philippines) and banana (Sri Lanka). The key diseases were anthracnose in mango and banana, caused by *Colletotrichum gloeosporioides* and *C. musae*, respectively, and stem-end rot in mango, caused by *Botryosphaeria* spp.

A significant component was to identify and evaluate activators of plant defences under field conditions. The activators were known resistance-inducing agents, including acibenzolar-S-methyl (Bion®), and elicitors derived from fungal pathogens (in banana). Another component was to characterise some of the key biochemical defences contributing to the resistance, and to identify treatments, varietal properties or other agronomic practices which may influence their relative concentrations. The final key objective was to enhance the capacity of project teams to conduct plant defence research, and provide information to respective industries via workshops and field days.

Mango was the crop common to project activities in Australia, Sri Lanka and The Philippines. In field trials, Bion® was the most consistently effective activator of resistance to anthracnose disease, when applied as a foliar spray or as a soil drench 3-5 times throughout the fruiting period. There is clearly the potential for reducing the number of fungicides applied in a given season if Bion® is applied. UV-C treatment to harvested mango activated biochemical defences and reduced anthracnose.

Another key finding from field trials in Australia (cv. Keitt) and Sri Lanka (cv. Karuthacolomban) was that increasing nitrogen fertilisation enhances anthracnose levels in fruit, which was correlated with high skin nitrogen and lower levels of preformed alk(en)ylresorcinols in skin tissue. Some mango cultivars (and rootstocks) consistently showed high levels of resistance to anthracnose, eg. ‘Keitt’ in Australia and ‘Gira’ and ‘Karuthacolomban’ in Sri Lanka.

There was some correlation between resistance amongst varieties and levels of constitutive defences. In Sri Lanka the galloyltannin class of compounds was identified to be a major component contributing to antifungal activity in mango peel extracts. The capacity to analyse the alk(en)ylresorcinol compounds was made possible after establishing collaboration with an expert in Poland.

All banana work was conducted in Sri Lanka. The existence and partial characterisation of several phenylphenalone-type phytoalexins accumulating in response to infection with *Phyllosticta musarum*, the pathogen causing freckle disease, was confirmed. Freckle infection also induced other biochemical defences, like PR proteins, phenolics and other structural defences.

A banana leaf bioassay system was developed for assessing resistance-inducing capacity of elicitors derived from the banana freckle and anthracnose (*Colletotrichum musae*) pathogens, and the active components were identified as 5-C polysaccharides (with a protein component for the *C. musae* elicitor). In field trials, preharvest treatment with Bion® and salicylic acid reduced anthracnose and crown rot, and stalk-end rot was also reduced by salicylic acid.

Fertiliser field trials demonstrated that increased nitrogen enhances anthracnose, while application of potassium reduced anthracnose and finger-end rot, particularly in soils with low initial levels of potassium. As with mango, cultivar differences in the resistance (or susceptibility) to anthracnose were demonstrated.

It is recommended that further field trials focus on the incorporation of Bion® into field disease management programs, but its registration and adoption remains the decision of Syngenta. Other defence activators should be assessed as they become available. Postharvest UV-C treatment should be assessed under commercial packingline conditions, and it is hoped that this will have application to disease management in mango in the near future.

The information on nitrogen fertilisation in banana and mango could have immediate impact if made widely available to growers and other agricultural/extension staff. The short-term impact of the variety work is that growers/industry could choose more disease resistant varieties. In the longer term, the selection and adoption of more resistant rootstocks (mango) is feasible and the work on biochemical defences could lead to the development of assays for screening germplasm for resistance as part of a breeding program.

The global knowledge of natural plant defence and what affects it has been significantly enhanced in this project, and the capacity of all project teams to conduct such research has been elevated. Some information is available immediately to industry and has been disseminated via workshops and field days.

LWR/2007/212 Opportunities to improve land and water management practices in Bhutan

Bilateral

Overseas Collaborating Countries	Bhutan
Commissioned Agent	Prof Peter Cornish (Private Consultant)
Project Leader	Prof Peter Cornish p.cornish@uws.edu.au
Project Budget	$25,750
Project Duration	15 May 2007–15 July 2007
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

The usable land resource in the mountainous Kingdom of Bhutan is limited; arable land makes up less than 8% of Bhutan's territory, and most of it located in the central valleys and southern foothills. Average rainfall is around 4000 mm/year but it is unevenly distributed over time and space, leading to seasonal and local imbalances. There are localised and seasonal water shortages for drinking and agricultural purposes – only about 12.5% of the arable land is irrigated.

The fluctuation between lean season and monsoon season flows is on the rise, leading to sub-optimal utilisation of generating capacity of hydropower plants. The increasing sediment load in rivers is decreasing the expected output and economic life of the hydro power plants. Floods and landslides are two major threats that emanate from the monsoon-dominated climatic setting.

This scoping study addressed some of the above land and water management issues. It originated from a meeting of an ACIAR team in December 2005 with the Agriculture Minister, Bhutan Lyonpo Sangay Ngedup. As an initial step ACIAR funded the study to explore options for improving land and water management practices.

The main output of the activity is a report making recommendations to the Royal Government of Bhutan on possible actions for improved land and water management practices, specifically in relation to surface water and watershed protection, water harvesting and water balance, improved cropping/farming practices and improved water-use efficiency.

Project outcomes

Final report not yet submitted by Commissioned Agent.

17 ACIAR Publications

This is a list of ACIAR publications produced in 2006-07. Print copies are available by emailing comms@aciar.gov.au, or electronic versions may be downloaded from ACIAR's website www.aciar.gov.au.

Monographs	
119a	Guidelines for surveillance for plant pests in Asia and the Pacific [Indonesian translation]. Teresa McMaugh, Indonesian translation by Andi Trisyono, 2007, 192 pp.
123a	Agricultural development and land policy in Vietnam [Vietnamese translation]. Sally P. Marsh, T. Gordon MacAuley and Pham Van Hung (eds), Vietnamese translation by Pham Van Hung, 2007, 272 pp.
124	Economically important sharks and rays of Indonesia. W.T. White, P.R. Last, J.D. Stevens, G.K. Yearsley, Fahmi and Dharmadi, 2006, 330 pp.
125	Aquaculture in Papua New Guinea: status of freshwater fish farming. Paul T. Smith (ed.), 2007, 123 pp.
126	Agricultural development and land policy in Vietnam: policy briefs. Sally P. Marsh, T. Gordon MacAulay and Pham Van Hung (eds), Vietnamese translation by P.V. Hung, 2007, 72 pp.
127	Postlarval fish capture and grow-out. Cathy Hair, Regon Warren, Ambo Tewaki and Ronnie Posalo, illustrated by Kisi Mae, 2007, 32 pp.

Proceedings	
122	Improving yield and economic viability of peanut production in Papua New Guinea and Australia. Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ranakrishna (eds), 2006, 118 pp.
124	Heart rot and root rot in tropical Acacia plantations. Karina Potter, Anto Rimbawanto and Chris Beadle (eds), 2006, 92 pp.
125	Coconut revival: new possibilities for the 'tree of life'. S.W. Adkins, M. Foale and Y.M.S. Samosir (eds), 2006, 104 pp.

Technical Reports	
64	Towards improving profitability of teak in integrated smallholder farming systems in northern Laos. Stephen Midgley, Michael Blyth, Khamphone Mounlamai, Dao Midgley and Alan Brown, 2007, 96 pp.
65	A review of animal health research opportunities in Nusa Tenggara Timur and Nusa Tenggara Barat provinces, eastern Indonesia. Bruce M. Christie, 2007, 76 pp.
66	Modelling minimum residue thresholds for soil conservation benefits in tropical, semi-arid cropping systems. M.E. Probert, 2007, 36 pp.

Working Papers	
62	Report on a review of ACIAR-funded projects on Rhizobium during 1983–2004. David F. Herridge, 2006, 48 pp.
63	Economics and market analysis of the live reef-fish trade in the Asia–Pacific region. Brian Johnston (ed.), 2007, 172 pp.

Impact Assessment Series Reports	
44	Impact assessment of capacity building and training: assessment framework and two case studies. Jenny Gordon and Kevin Chadwick, 2007, 120 pp.
45	Development of sustainable forestry plantations in China: a review. John W. Turnbull, 2007, 78 pp.
46	Mite pests of honey bees in the Asia–Pacific region. Michael Monck and David Pearce, 2007, 32 pp.
47	Improved Australian tree species for Vietnam. Hayden Fisher and Jenny Gordon, 2007, 36 pp.
48	Assessment of capacity building: overcoming production constraints to sorghum in rainfed environments in India and Australia. Chloe Longmore, M. Cynthia Bantilan and Jenny Gordon, 2007, 44 pp.
49	Minimising impacts of fungal disease of eucalypts in South-East Asia. Hayden Fisher and Jenny Gordon, 2007, 36 pp.
50	Improved trade in mangoes from the Philippines, Thailand and Australia. Michael Monck and David Pearce, 2007, 48 pp.
51	Growing trees on salt-affected land. James Corbishley and David Pearce, 2007, 44 pp.

Corporate publications	
	ACIAR Annual Report 2005–06. October 2006
	ACIAR Annual Operational Plan 2007–08. June 2007
	Adoption of ACIAR project outputs: studies of projects completed in 2002–2003. J. Gordon and J. Davis (eds), 2007, 64 pp.
	ACIAR Publications Catalogue 2007
	Partners in Research for Development magazine Winter 2006 Spring 2006 March–June 2007 July–October 2007
	More crop per drop from Australian International Research (Report on how Australian benefits from ACIAR water research)

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