Country Profile

South Asia

November 2006

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 and development between Australian and developing country institutions in areas where Australia has special competence. It also administers Australia's contribution to the International Agricultural Research Centres.

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Contents

Preface

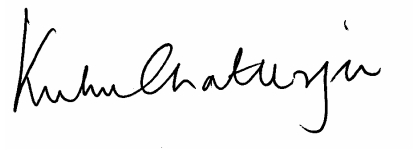
The ACIAR Country Profiles are designed as a snapshot of the collaborative research being carried out between Australia and our various partner countries. This publication contains short summaries of both bilateral and multilateral projects with India, Pakistan, Bangladesh and other South Asian countries (Afghanistan, Bhutan, Nepal and Sri Lanka) that were active at 30 June 2006. There were 24 bilateral and 7 multilateral projects, the latter being led by an international agricultural research centre. As well, 13 new projects were under development, many of which are expected to start in the next 12 months.

This publication also sets out the key outputs from 3 bilateral and 2 multilateral projects that have been completed since 30 June 2006.

As well as these project summaries, the publication includes extracts from ACIAR's 2005–06 Annual Report covering South Asia, our near-term program as outlined in the 2006–07 Annual Operational Plan, and a record of the most recent formal consultations held between ACIAR and India on the medium-term priorities for the joint program. There have been no recent consultations in other South Asian countries.

ACIAR will produce similar profiles each year and distribute them to key stakeholders in our South Asian partner countries and Australia.

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



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South Asia Reports 2005–06

(extracts from ACIAR Annual Report 2005–06)

India

Active projects in 2005–06	26
AOP budgeted expenditure in 2005–06	$2,415,000
Actual bilateral country expenditure in 2005–06	$2,018,915
Bilateral country expenditure in 2004–05	$2,601,365
Bilateral country expenditure in 2003–04	$2,482,097

Key performance indicators	Performance 2005–06
• Commencement of two projects on sustainable natural resource management involving poor communities in eastern India	One new project has been initiated (SMCN/2002/100: *Water harvesting and better cropping systems for the benefit of small farmers in watersheds of the East India Plateau*). The project has started work with several communities, and a plan for the implementation of improved cropping and water harvesting interventions in the next Kharif season have been agreed, with participation by the villagers. A second water harvesting project in Andhra Pradesh was due to be initiated in 2006 but was rejected at the ACIAR in-house review due to design flaws.
• Involvement of NGO groups in at least two new projects	The single new project initiated in 2005–06 (SMCN/2002/100) has the Indian team led by PRADAN, a major NGO.
• Extension of new low-salt hide processing technique to several tanneries in extended pilot phase	The project engaged with 20 tanners and the preliminary assessment of the procedures and approaches was conducted by a high profile tanner. Uptake by a wider group of tanners is still limited, although this should be facilitated by involvement at an industry workshop in mid 2006.
• Analysis of genotype by environment interaction in Indian national chickpea trials finalised, thereby permitting more efficient deployment of testing resources	The training of Indian scientists in the detailed analysis of the effects of genotype x environment (G x E) of on chickpea genotypes in their breeding programs has now been completed. The Indian scientists have now used new statistical analysis tools to improve the efficiency in selecting appropriate genotypes from the breeding programs.
• Confirmation of 'greening' as a major factor in citrus decline in Sikkim and adjacent regions, leading to more informed management of decline	Independent reviewers of project HORT/2002/030 found that a key achievement was confirmation of widespread greening in all mandarin production regions of Sikkim, and that this is a major limitation to production. This has resulted in recommendations for changes to management practices, including use of disease-free planting material and control of the disease vector. An indirect outcome of HORT/1997/101 in Bhutan has been an increasing awareness amongst growers of the occurrence of greening and the need for integrated control measures.
• 40% of new projects designed to have significant farmer or policy-maker impacts within 5 years of completion	The single project initiated in India in 2005–06 (SMCN/2002/100) has been designed to have significant farmer impacts within 5 years of completion.

Position

India faces huge problems in its rural sector even as the overall economy forges ahead—the greatest number of poor and undernourished in any country is found in India. The emphasis of ACIAR's India program is on sustainable smallholder production of crops through application of better management technologies, and analysis of policy constraints and options. Broad-scale land and water resource management work emphasises technical and policy research on water management. The program aims to underpin continued high production in favoured lands as well as boost sustainable production in more marginal lands.

India's large, well developed national agricultural research system centres around the Indian Council for Agricultural Research (ICAR), which has collaborated strongly in ACIAR projects. Also, during 2005–06 ACIAR has fostered partnerships with state agricultural universities and government research institutes, working together on projects that are led by Indian Independent Research Organisations (IROs) and NGOs. Projects increasingly emphasise achieving practical farmer-level and policy impacts, particularly in poorer regions of India. ACIAR engages mainly with centres in north and central India, where research projects are presently under way to manage scarce water and nutrient resources more efficiently, improve yield and quality of grains and legumes, and to diversify production and raise farm incomes.

Achievements

Transient water logging can occur during wheat production; it affects 4.5 million hectares in India (also 0.5 m hectares in south-western Australia) each year. Drainage systems, used in intensive agriculture, are not cost-effective in extensive broad-acre cropping systems, and breeding of waterlogging-tolerant wheat cultivars for India's resource-poor farmers is seen as the sustainable means of improving crop yields. A project has provided a new understanding of the complexity of the problems affecting the growth and productivity of **wheat under waterlogged conditions** in a range of specific environments in both countries. This new understanding has given a sound scientific basis for rapid advancement in developing highly tolerant cultivars.

Salinity and waterlogging, caused by rising watertables, bring water of variable quality to the surface in parts of India and Australia. If it contains too much salt it can render agricultural land unproductive. In such circumstances aquaculture is possible in holding ponds, using waters drawn from low aquifers. Good management is critical, and a project is addressing some of the constraints such as variability in concentration and composition of salts. The scientists are testing marine species with commercial potential—such as fish, crustaceans, shellfish and edible seaweed. The project will help to **integrate aquaculture into areas with degraded farmlands** and, by diverting the salt into aquaculture, also lift the capacity for agricultural activities.

Sikkim in northern India once had a thriving **mandarin industry**, and citrus remains the region's most important horticultural crop. Although there is a large and lucrative market, producers have been hampered by what was thought to be **huanglongbing** (HLB), a debilitating insect-transmitted citrus disease of the tropics and subtropics. A project to address these problems has determined that HLB is widespread in all mandarin-growing areas. One hundred resistant genotypes, both scion and rootstock, have been introduced for the mandarin industry, and a modern nursery in Linjok, Sikkim is now poised to distribute commercial numbers of high-health grafted mandarins to the industry. Capacity has developed in field surveillance and identification of disease, and sample preparation for laboratory testing. Farmers and industry practitioners have received training in modern citrus production techniques.

Plant breeders have traditionally paid little attention to the quality of crop residues, which are a major source of fodder for livestock. Now a project bringing together plant breeders (ICRISAT) and livestock nutritionists (ILRI) aims to improve animal productivity in crop–livestock systems in the driest rainfed parts of India, where pearl millet (*Pennisetum glaucum*) is the only reliably productive cereal. The researchers aim to use both marker-assisted and conventional plant breeding to genetically **increase the nutritive value of pearl millet** stover. Already the scientists have linked laboratory-quality traits for the stover with livestock-productivity measurements, an essential prerequisite for a program of genetic improvement.

The States of Andhra Pradesh, Karnataka and Maharashtra share the **water in India's Krishna River Basin**. Through IWMI, they are receiving assistance from an ACIAR project, which is helping to develop an integrated framework to formulate and evaluate water allocation strategies, based on historical and hydrological data. The project has integrated both biophysical and socioeconomic assessments to ascertain how to maintain quantity and quality of supply while allocating water to irrigation, urban and industrial uses for maximum economic benefit. The information being generated will also help the Krishna Basin Tribunal in its decision making.

For a decade ACIAR has invested in projects to increase sheep meat production in India through **improvements in efficiency of sheep rearing**. The work has identified a genetic basis for certain breeds of sheep that regularly produce twins, a trait highly prized by local shepherds. Two potentially prolific genotypes, *Fecund Deccani* and *NARI composite* are now being trialled in shepherds' flocks. The project has been extended to enable more complete analysis of performance of the new genotypes and to evaluate the socioeconomic benefit arising from wider distribution of the new genotypes.

Work is being completed on the development of **new technologies to lift milk production** in village cattle and buffaloes. Progress was made in improving ruminant digestion of fibre to gain maximum nutritional benefit from poor-quality roughage. Scientists have identified a fungus with superior qualities to the fungi that naturally colonise the rumen in breaking down the fibre. Inoculating the rumen with the better fungus, together with nutritional supplements that stimulate fungal efficiency should realise gains of up to 10 per cent in cattle productivity.

Environmental damage from effluents discharged by the **tanning industry** in Tamil Nadu in southern India has led to the closure of many tanneries. Now research has produced workable solutions that drastically reduce the amount of salt, chromium and other contaminants released. Researchers have shown that fresh skins can be treated with 20 per cent of the salt previously used, and chilling to preserve them until tanning (a widely used method in Australia) is a feasible option. Another breakthrough has been to show that two tanning products, pickle liquor and chrome liquor, can be re-used indefinitely instead of discarding after every treatment.

Pakistan

Active projects in 2005–06	7
AOP budgeted expenditure in 2005–06	$500,000
Actual bilateral country expenditure in 2005–06	$1,045,668*
Bilateral country expenditure in 2004–05	$506,033
Bilateral country expenditure in 2003–04	$697,496

*Increased expenditure associated with a new major project with AusAID: Australia–Pakistan Agriculture Sector Linkages Program (ASLP)

Key performance indicators	Performance 2005–06
• Adoption of bed planting for maize and wheat by first two cluster groups of farmers in Mardan and meeting of machinery repayments	The two cluster groups have continued using bed planting, with consistently higher yields and irrigation water savings. Their support remains high, and repayments are on schedule, and an additional two cluster groups have been selected and are due to receive the first Pakistan-made bed machinery. Following the visit to project sites by the Federal Minister for Agriculture, the project team was asked to submit a proposal to the Government of Pakistan to establish a national raised beds dissemination program.
• Successful completion of initial trials on serial biological concentration of irrigation drainage water	Construction of both serial biological concentration sites was completed by June 2005. A maize crop was planted in August at both sites for summer 2005, and the crop and water monitoring protocols were implemented. Unfortunately, torrential rains at both sites ruined the initial crop, so despite reasonable establishment, no yield data were obtained. A high-yielding winter wheat crop was subsequently obtained at both sites.

Position

Pakistan has been an ACIAR partner country since 1984. The areas of major emphasis in the past have been management of irrigation and drainage and management of agriculture and forestry on saline soils, within a broader focus on overcoming biotic and abiotic constraints in broadacre crop production. There are also areas of common interest and comparative advantage in livestock production and health.

In 2005–06 ACIAR took responsibility (on behalf of AusAID) for implementing the Australia-Pakistan Agriculture Sector Linkages Program (ASLP), designed to transfer Australian knowledge and expertise to key sectors of Pakistan agribusiness to increase profitability and enhance export potential. Its objectives are poverty reduction for smallholder farmers through collaborative research and development and enhancing the capacity of the Pakistan research, development and extension system to deliver targeted and practical research outputs to agribusiness and farmers.

Achievements

A project to refine and adopt **permanent raised bed (PRB) technology** for the irrigated maize–wheat cropping system in Pakistan is continuing to make excellent progress. The two heads of the farmer cluster groups indicated that there are many farmers from outside the groups requesting the Australian-designed bed planters for use on their farms. The additional demand is presently surpassing the ability of the groups to supply. Following the successful proof-of-concept of the project, the Australian High Commissioner promoted the project as something worthy of Government of Pakistan investment. In August 2005, the Minister of Food, Agriculture and Livestock (MINFAL) inspected the project and his interactions with the cluster groups prompted MINFAL to ask the Pakistan project leader for a proposal to **develop an outreach program** to more broadly disseminate PRBs and the cluster group model to other provinces. MINFAL has agreed to the proposal and a roll-out of the project is scheduled for July 2006. A related activity is underpinning the sustainable development of PRB systems in Asia and Australia. That project is developing **criteria for optimising bed design** from analytical and numerical modelling of water and solute transport in permanent raised beds, also using models to design placement strategies that maximise fertiliser usage and minimise leaching to groundwater, as well as determining whether salinisation of the beds is likely under certain scenarios.

Scientists are identifying cropping options to use in a **serial biological concentration system** as a way of managing saline irrigation effluent, which normally goes directly into rivers. Part of the process is to trial fish and seaweed species suitable for cultivation in the effluent. Two serial biological concentration demonstration sites are now established in Punjab and Sindh provinces. In Australia, the scientists are developing a framework to assist in the selection of the best management system for each in a range of saline drainage effluents. The options for managing sub-surface drainage and implications for salt mobilisation have been grouped into four categories—reduce subsurface drainage, redistribute the effluent throughout the region, store locally or manage the export of salt to the river in stages.

One of the first activities undertaken as part of the Agricultural Sector Linkage Program (ASLP)—see box—was a Small Research Activity that brought together stakeholders involved in **mango RD&E** in Pakistan and Australia. Working with Pakistani counterparts, Australian mango R&D specialists and a mango farmer reviewed RD&E activities in the Pakistan mango industry, with the aim of identifying issues suitable for undertaking within the ASLP. A major focus was control of mango sudden death syndrome (MSDS) which is reducing productivity in some orchards by more than 20 per cent. Survey visits followed the workshop, and the findings are being incorporated into a new ACIAR project, *Development of integrated crop management practices to increase sustainable yield and quality of mangoes in Pakistan and Australia*.

New era of Australian–Pakistan agricultural cooperation

In June 2005 the Minister for Foreign Affairs, the Hon Alexander Downer MP, and the then Minister for Agriculture, Fisheries and Forestry, the Hon Warren Truss MP, announced a new program for cooperation on several fronts, including agriculture, between Pakistan and Australia. The scheme arose from discussions between Prime Minister John Howard and the President of Pakistan Pervez Musharraf during a visit to Australia by President Musharraf. ACIAR is managing the agricultural component, known as the **Australia–Pakistan Agriculture Sector Linkages Program (ASLP)**, and during 2005–06 the new initiatives gained momentum.

The main goals of ASLP 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.

Consultations between ACIAR and Pakistani stakeholders led to agreement to collaborate on two new thematic priorities—horticulture and dairy. The following research thrusts have priority: increasing mango and citrus production, through diagnosis and control of diseases and orchard management to increase productivity and reduce input costs; supply-chain enhancement, including value-adding and marketing for the mango and citrus industries; and increasing milk production from individual animals.

To meet the ASLP goals and to ensure the program delivers early impacts, the program is being configured into a flexible suite of 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. New projects include significant components of capacity-building in participatory research and extension methodologies.

ACIAR's core program complements the ASLP through a broader focus on land and water resources, encompassing community-driven water allocation and drainage management as well as dryland and irrigated cereal production.

Bangladesh

Active projects in 2005–06	3
AOP budgeted expenditure in 2005–06	$267,000
Actual bilateral country expenditure in 2005–06	$371,464
Bilateral country expenditure in 2004–05	$243,712
Bilateral country expenditure in 2003–04	$276,729

Key performance indicators	Performance 2005–06
• Opportunities for additional project investments explored and agreed in Bangladesh	A new project aimed at increasing livelihoods in NW Bangladesh by reinvigorating the production of winter legumes in rice-fallow systems (SMCN2005/001 *Addressing legume constraints in cereals-based cropping systems, with particular reference to poverty alleviation in north-western Bangladesh*) has been developed for commencement in late 2006. A second opportunity for intensification of rice-fallow systems by introducing winter wheat (this time in the hotter, southern areas of Bangladesh) was explored further through SMCN/2005/042 *Scoping study to assess the technical and economic feasibility of wheat production in southern Bangladesh*. The results were of sufficient promise to encourage systematic testing of the feasibility of wheat production.
• Adoption of integrated disease and pest control packages in over half the traditional chickpea-growing districts of the western region	100 demonstrations trials of the optimum ICM package for chickpea planned for the districts of Jessore, Jhenaidah, Magura, Rajbari and Faridpur. In each district yields of chickpea were competitive with other winter field crops, both dry-land and irrigated. However constraints due to collar rot, pod borer damage and rainfall near harvest occurred. More stable yields of chickpea will depend on adequate management of collar rot and pod borer, in addition to botrytis grey mould, especially in years with substantial rainfall during the growing period.

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.

ACIAR's strategy in Bangladesh is to focus on agronomic and biotic constraints to the production of broadacre grain crops, especially the rabi (winter season) crops. It does this through both bilateral and IARC-led projects that link to existing programs such as the CGIAR-coordinated Rice–Wheat Consortium.

Achievements

A four-year project involving ICRISAT focused on integrated management of Botrytis Grey Mould (BGM) of chickpea, which is a major constraint for production in Bangladesh. Its overall aim was to **optimise the cultivation of chickpea** in traditional chickpea-growing areas of Bangladesh, where the area of crop sown has decreased significantly, primarily due to BGM. The project has contributed towards arresting the decline of chickpea production in Bangladesh, mainly by developing integrated management packages, raising awareness of farmers, and by on-farm and researcher training.

A related project involving ICARDA recognises the **importance of legumes in the crop cycle**. It is introducing plant health management packages for faba bean, chickpea and lentil, and seeking to improve resistance to certain diseases and stresses. Several additional new sources of resistance to major diseases affecting pulse crops were identified at ICARDA and will be shared among national breeding programs. Work undertaken at Horsham, with the Department of Primary Industry,Victoria to screen lentil and chickpea germplasm for resistance has revealed a wide range of reactions to BGM. Results were encouraging, and breeding lines with the Canadian cultivar 'Indianhead' as a parent appeared to be most resistant to infection by *Botrytis* species.

Other South Asian Countries

Active projects in 2005–06	6
AOP budgeted expenditure in 2005–06	$488,000*
Actual bilateral country expenditure in 2005–06	$68,131*#
Bilateral country expenditure in 2004–05	$436,885*
Bilateral country expenditure in 2003–04	$526,575*

*The Annual Operational Plan grouped Afghanistan, Bhutan, Nepal, Iraq and Sri Lanka together under Other South Asia, for budgeting and reporting purposes. Bilateral expenditure figures for these countries are grouped together in the table above. Similarly, key performance indicators for Other South Asia were grouped together and are reported against below.

Actual expenditure is lower then forecast in the AOP due to difficulties associated with undertaking the horticulture project in Iraq.

Key performance indicators	**Performance 2005-06**
• Improvements in lentil yields confirmed in rice–legume rotations in Nepal	The results of on-farm trials have shown that the new genotypes have an average of 12% increase in yield over the local varieties that farmers use. This has led to the release of new higher-yielding varieties for the farmers in the region.
• Field control programs for citrus fruitfly established in Bhutan	Through project HORT/1997/101, a field control program for Chinese citrus fruit fly in Bhutan has been developed which reduced fruit damage to 2–5%. This program applies two carefully timed cover sprays of dimethoate and collects fallen fruit from the ground at 10 day intervals. This strategy has been promoted to growers through the 'National Citrus Campaign' under Government Executive Order.
• Successful trials of management strategies to reduce fungal disease incidence in mangoes in Sri Lanka	In project HORT/1997/094 pre- and post- harvest treatments of mango fruit with natural defence stimulators (Bion, salicylic acid, potassium silicate) and exposure to UV-C radiation reduced fungal diseases and increased fruit shelf life. Nitrogen fertilizer application to trees close to harvest increased the incidence of fruit diseases while potassium fertilizers had the reverse effect.
• Initiation of two projects in Iraq that address key food security and agricultural sustainability issues	Two projects that assist in improved production of food crops in Iraq are under way: CIM/2004/024, focusing on *crop germplasm and management for improved production of wheat, barley and forage legumes* and HORT/2004/101, aimed to improve management of a major insect pest of citrus and dates.

Bhutan

Position

ACIAR's small program with Bhutan began in 1998. Because of Australia's relatively low comparative advantage, the program remains very 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.

Achievements

The major active project, a **survey of fruit flies** in Bhutan and a **field control program for the Chinese citrus fly**, was favourably reviewed. The Chinese fruit fly (*Bactrocera minax*) was confirmed as a devastating pest of the mandarin industry in Bhutan, with estimated losses of up to 80 per cent and averaging around 20 per cent every year. *B minax* is unique among fruit flies in having only one life cycle per year. Eggs hatch in June–July and larvae emerge after fruit drop in late autumn; the pupae then overwinter in the soil before emergence next spring. Researchers found that the males did not respond to pheromone lures, as is the case with other flies, making it extremely difficult to control. Monitoring of this pest was only possible using liquid protein traps that are highly labour-intensive to maintain.

The research team collected hundreds of specimens comprising 26 fruit fly species, then identified them and established a referral collection at the National Plant Protection Centre, Bhutan. They discovered three species of economic importance and two new species of fruit fly. Based on the research findings, a field control strategy was developed integrating two-timed cover sprays with collection of fallen fruits every 10 days. This control strategy was promoted on a national scale through the National Citrus Campaign in 2005 following an Executive Order.

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 has had a small program 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. New projects are not being considered at this time.

Achievements

Lentils and another legume called grasspea (*Lathyrus sativus*) are widely grown in the lower areas of Nepal. Work has continued to identify **better adapted germplasm** that can withstand both waterlogging and drought at different stages, as well as resisting fungal wilt. *Lathyrus* is potentially toxic, and varieties with a lower toxin concentration would be safer for livestock and human consumption. The project has selected and propagated improved varieties of both species.

Numerous trials involving promising lines or varieties of lentils have been conducted in a number of locations, particularly in the terai (where 95 per cent of the lentils are grown in Nepal). The work has resulted in many promising lines that can either be directly released to farmers as cultivars or used as parents in the breeding programs. The project has made impact on a considerable number of Nepali farmers. Some are already growing the improved lentil varieties and 1000 or so have taken up the promising line ILL7723. This should lead to significant economic benefits through sales of surpluses. The seed priming methods developed for lentil grown following rice harvest are now being adopted by farmers; the Department of Agriculture (DOA) is making recommendations for their adoption more widely.

Currently, the project team is monitoring uptake and impact of the new technologies. Researchers aim to further improve the productivity and profitability of lentil production and also facilitate the improvement of *Lathyrus*, both as an animal feed and human food.

Sri Lanka

Position

Sri Lanka was one of ACIAR's original partners; the high quality of training of many Sri Lankan agricultural scientists facilitated development of the program. Most collaboration has been in animal sciences, especially animal health. Other areas have included fisheries, farming systems economics, agricultural development policy, crop sciences, forestry and crop postharvest technology.

Completed projects include an economic study into optimal land use, which developed policies to avoid land degradation in upland plantation areas, as well as a practical model that demonstrated the need to replant/rehabilitate tea plantations to avoid erosion. Some project outputs have been incorporated into new Asian Development Bank-funded projects. Other research topics have included economic and simulation modelling of rice-based cropping systems, and one that led to successful biological control of *Salvinia* waterweed. New projects are not being considered at this time.

Achievements

The only active project seeks to improve strategies for managing **postharvest diseases of subtropical and tropical fruit**. Current programs do not reliably control disease during retail marketing and export. Until recently little attention had been given to the powerful defence mechanisms that plants have evolved to limit and prevent disease on developing fruit. In this project Sri Lankan and Australian scientists have worked to characterise resistance mechanisms.

The scientists in Sri Lanka are assessing the role of constitutive and induced host defence mechanisms in extending the shelf-life of mango fruit. They are also developing treatments or practices that can be used in the management of the major postharvest diseases of banana, and seeking to improve current understanding of interaction between banana and the freckle pathogen (*Phyllosticta musarum*), culminating in enhanced resistance to the damaging disease anthracnose. Agriculturists have tested treatments and worked with farmers to enhance resistance and thus suppress disease development on mangoes during production and marketing.

Afghanistan

Position

Two decades of war coupled with the worst drought in 40 years have 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 work in Afghanistan provides short- to medium-term support to wheat and maize production—wheat being by far the most important crop and maize the third most important. This objective is being achieved principally by providing seed of suitable cultivars via import, establishing on-farm participatory testing of imported germplasm to identify better-adapted improved cultivars, followed by local multiplication and distribution of the chosen cultivars. Special attention is given **to yellow rust resistance in wheat** and to promoting **improved crop management** along with the **improved cultivars**. The projects are co-funded by AusAID and ACIAR, managed by ACIAR and executed by CIMMYT.

Achievements

In collaboration with the Agricultural Research Institute of Afghanistan (ARIA), the project obtained several screening nurseries and yield trials from International Agricultural Research Centres. These trials were composed of experimental and commercially available **maize and wheat germplasm** adapted to the Afghan agro-ecological conditions. After harvest and trial data analysis, project officers discussed the results with scientists from ARIA and collaborators from FAO. Twenty-seven promising wheat lines and a group of experimental subtropical maize cultivars have been identified for further testing. Of particular interest were CIMMYT wheat experimental materials selected in Iran in 2002—one in particular gave early indication of excellent resistance to rust and superior yield compared with the local varieties.

Although results of informal **seed multiplication schemes** are difficult to obtain due to the security situation in the country, there is anecdotal evidence that farmers who planted some of the project's open-pollinated cultivars in 2003 had bartered and sold more then two tonnes of these varieties in 2004. The area under improved varieties was then multiplied by more then 10-fold as a result of this resilient farmer-to-farmer seed distribution system.

The project has built human capacity through **technical workshops** conducted nationally. They have covered topics such as potential and constraints to agricultural development in Daikundi, introduction and discussion of yellow rust and practical exercises for scoring in the field, and an introduction to CIMMYT's work, research methodologies and variety evaluation, together with a field day. Farmers, NGO workers and officers from research stations have attended these workshops.

Iraq

Position

High levels of input subsidies, guaranteed commodity prices and free food distribution have distorted agricultural markets in Iraq and left 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, ACIAR has developed projects designed to assist the Iraqi Government in its quest to modernise agricultural production systems and markets.

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 focuses on the enhancement of barley, wheat and grain legume production under dryland conditions in northern Iraq. In another project Australian scientists are helping Iraqi senior scientists to develop a National Strategy Plan for the control of jasmine whitefly affecting citrus production in central Iraq; as part of the Plan junior scientists are receiving training in Australia in integrated pest management practices that they can implement on return to Iraq.

Achievements

The first stage of the project to study **jasmine whitefly** that affects citrus production in Iraq involved a workshop held in Australia in August 2005. Participants at the workshop comprised six senior scientists from Iraq and nine from Australia. Together they developed a strategic framework for pest management in Iraq. The plan comprises a five-year schedule with critical success factors, indicators, and strategies and an implementation plan, with actions for each strategy. Short-term recommendations have been made for each critical success factor and are actions that can be taken independent of the situation in Iraq. It has been formally accepted by the Iraqi Government. More specifically they also developed a National Strategic Plan for the management of jasmine whitefly in citrus for the citrus/date systems in Iraq.

Work has begun in a project to improve production of **wheat and barley,** as well as **pulse and forage legumes** in Iraq. The research is focusing on assistance to farmers by identifying and disseminating suitable varieties from within Iraq, as well as varieties from collections at ICARDA and in Australia, emphasising farmer participation from northern Iraq's rainfed cropping regions. Iraqi scientists are also being supported to attend appropriate international workshops.

South Asia Plans 2006–07

(extracts from ACIAR Annual Operational Plan 20056–07)

India

GNI per capita[1]		Bilateral actual 2004–05*	$2.51m
Population[2]	1,103.4 million	Bilateral forecast 2005–06**	$2.42m
Population 2015/2050[3]	1,260.4 / 1,592.7 million	Bilateral budget 2006–07**	$2.33m
Active bilateral projects	16	Bilateral + Multilateral budget 2006-07	$2.99m
Active multilateral projects	4		

**Includes co-funding of projects ($0.08m in 2004-05, $0.09m in 2005–06 and $0.09m in 2006-07) by the Grains R&D Corporation.

Medium-term strategy

The emphasis of ACIAR's India program is on sustainable smallholder production of crops and livestock through application of better genotypes, better management technologies, and analysis of policy constraints and options. Broad-scale land and water resource management work emphasises technical and policy research on water management. The program aims to underpin continued high production in favoured lands as well as boost sustainable production in more marginal lands. During 2006–07 there will be an increased focus on developing projects that involve farmers and farmer groups, and 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 with a longer lag to farmer impact. Where relevant, projects will be linked to the CGIAR-coordinated regional Rice–Wheat consortium for broader impact.

Key performance indicators (2006-07)

- Significant involvement of farmers and farmer communities in planning and testing ACIAR project technologies in at least two projects.
- Policy workshops and papers in trade and water management reaching key government planners.
- Forward strategy for ACIAR involvement in the Indian livestock sector developed and communicated.
- Significant adoption by tanneries of salinity-reducing techniques for processing hides.
- A manual for best practice silviculture and nutrient management in Eucalyptus forests of southern India.
- Production constraints in soybean-wheat systems of Madhya Pradesh identified and appropriate research strategies implemented.
- Preliminary catchment water balances in the Krishna Basin quantified and used to inform water policy decision making at national and state levels.
- 40 per cent of new projects designed to have significant farmer or policymaker impacts within five years of completion.

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[1] Source: Commonwealth of Australia, *Australia's Overseas Aid Program 2006-07*, Statement by Minister Alexander Downer, May 2006.

[2] Source: United Nations Population Division, 2005, *World Population Prospects: The 2004 Revision*, http://www.un.org/esa/population/publications/WPP2004/World_Population_2004_chart.pdf.

[3] Source: United Nations Population Division, 2005, *World Population Prospects: The 2004 Revision*, http://www.un.org/esa/population/publications/WPP2004/World_Population_2004_chart.pdf.

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 in any country (approximately 250 million) are found in India, particularly in rural areas. At the same time India faces trade liberalization 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 northern 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 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, centre and east 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.

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, 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 in the NE 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. The Pakistan program also addresses increased productivity in selected agricultural sectors and management of the natural resource base, while the emphasis in Bangladesh on reducing constraints to production of grain crops directly addresses the shift in focus to underpinning increased food security.

Indicative priorities

ACIAR has a formal program of consultations with India to establish priorities in research collaboration. The most recent consultation was held in September 2001. Since then there have been ongoing discussions of priorities with Indian counterparts Identified thematic priorities are listed below, and the priorities are detailed more fully at www.aciar.gov.au under Partner Country Priorities/India.

Subprogram 1. Maintaining the competitiveness and sustainability of production in favoured areas which have access to resources and markets

- Adjusting to the challenges and opportunities of international trade
- Improving the supply and quality of major traded cereals and oilseeds
- Application of biotechnology to crop improvement
- Dealing with water scarcity in major irrigated systems

Subprogram 2. Increasing productivity in marginal areas with limited resources

- Improving the productivity of rainfed cropping systems and their integration with livestock production systems
- Strategies for water harvesting and sustainable utilization of small scale supplemental irrigation systems in semi-arid watersheds
- Informing water resource management and policy making to maximise water productivity
- Improving profitability of small ruminant-based livelihood systems.

Key program managers

Dr Ray Trewin, Agricultural Development Policy
Dr Peter Rolfe, Animal Health
Mr John Cullen, Crop Improvement and Management
Dr Christian Roth, Soil Management and Crop Nutrition

Country Manager

Dr Kuhu Chatterjee, ACIAR Regional Manager, South Asia

Pakistan

GNI per capita[4]	
Population[5]	157.9 million
Population 2015/2050[6]	193.4 / 304.7 million
Active bilateral projects	7
Active multilateral projects	1

Bilateral actual 2004–05	$0.51m
Bilateral forecast 2005–06	$0.50m
Bilateral budget 2006-07*	$2.01m
Bilateral + Multilateral budget 2006-07	$2.01m

*Includes AusAID–funded projects of $1.53m (budget 2006–07).

Medium-term strategy

ACIAR will broaden the past modest program of bilateral and multilateral projects in Pakistan, which have focused on major natural resource problems accompanying irrigated and dryland cereal cropping, such as efficient water use, salinity and drainage, and tillage, to a larger involvement encompassing the horticulture and dairy sectors. This broadened focus arises out of the Australia-Pakistan Agriculture Sector Linkages Program, which ACIAR is implementing on behalf of AusAID.

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 small-holder 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
- Supply chain enhancement, including value adding and marketing for the mango and citrus
- In the dairy sector, increasing milk production from individual animals.

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 expected outcome of the ASLP is to build stronger capacity in Pakistan to exploit agri-business 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.

[4]Source: Commonwealth of Australia, *Australia's Overseas Aid Program 2006-07*, Statement by Minister Alexander Downer, May 2006.

[5] Source: United Nations Population Division, 2005, *World Population Prospects: The 2004 Revision*, http://www.un.org/esa/population/publications/WPP2004/World_Population_2004_chart.pdf.

[6] Source: United Nations Population Division, 2005, *World Population Prospects: The 2004 Revision*, http://www.un.org/esa/population/publications/WPP2004/World_Population_2004_chart.pdf.

Key performance indicators (2006–07)

- ASLP program components implemented that address Pakistan priorities and optimal use of Australian technical expertise
- Government of Pakistan funded program to disseminate bed planting technology in other maize-wheat growing regions of Pakistan initiated
- Proof-of-concept of serial biological concentration of irrigation drainage water providing the basis for piloting in other districts of Punjab and Sindh provinces
- 40 per cent of new projects designed to have farmer or policy impacts within five years of completion

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.

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, 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 in the NE 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. The Pakistan program also addresses increased productivity in selected agricultural sectors and management of the natural resource base, while the emphasis in Bangladesh on reducing constraints to production of grain crops directly addresses the shift in focus to underpinning increased food security.

Thematic priorities

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

In 2006-07, new projects will be considered for the mango and citrus sector, and in the dairy production sector. New projects will include significant capacity building components in participatory research and extension methodologies.

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

Subprogram 2: Improving livelihoods of dairy farmers

- Increasing unit animal productivity of dairy cattle though improved nutrition
- Introduction and testing of improved dairy cattle and forage germplasm
- Supporting linkages between farmers and the private agribusiness 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 and rainfed horticultural and cereal-based farming systems

Key program managers

Mr Les Baxter, Horticulture
Dr Bill Winter, Livestock Production Systems
Dr Jeff Davis, Policy Linkages and Impact Assessment
Dr Christian Roth, Soil Management and Crop Nutrition

Country Manager

Dr Kuhu Chatterjee, ACIAR Regional Manager, South Asia

Bangladesh

GNI per capita[7]	
Population[8]	141.8 million
Population 2015/2050[9]	168.2 / 242.9 million
Active bilateral projects	1
Active multilateral projects	1

Bilateral actual 2004–05	$0.24m
Bilateral forecast 2005–06	$0.27m
Bilateral budget 2006–07	$0.41m
Bilateral + Multilateral budget 2006–07	$0.46m

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 and linking to their existing programs, for example under the CGIAR-coordinated Rice–Wheat consortium.

Key performance indicators (2006-07)

- Technical and economic feasibility of wheat production examined in southern Bangladesh, and options for further research and development determined
- Integrated legume research program designed and initiated

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.

[7] Source: Commonwealth of Australia, *Australia's Overseas Aid Program 2006-07*, Statement by Minister Alexander Downer, May 2006.

[8] Source: United Nations Population Division, 2005, *World Population Prospects: The 2004 Revision*, http://www.un.org/esa/population/publications/WPP2004/World_Population_2004_chart.pdf.

[9] Source: United Nations Population Division, 2005, *World Population Prospects: The 2004 Revision*, http://www.un.org/esa/population/publications/WPP2004/World_Population_2004_chart.pdf.

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, 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 in the NE 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. The Pakistan program also addresses increased productivity in selected agricultural sectors and management of the natural resource base, while the emphasis in Bangladesh on reducing constraints to production of grain crops directly addresses the shift in focus to underpinning increased food security.

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.

Key program managers

Mr John Cullen, Crop Improvement and Management
Dr Christian Roth, Soil Management and Crop Nutrition

Country Manager

Dr Kuhu Chatterjee, ACIAR Regional Manager, South Asia

Other South Asian and Middle East countries (including Iraq)

Population[10]	108.7 million	Bilateral actual 2004-05*	$0.44m
Population 2015/2050[11]	135.7 / 240.2 million	Bilateral forecast 2005–06**	$0.49m
Active bilateral projects	2	Bilateral budget 2006–07	$0.23m
Active multilateral projects	5	Bilateral + Multilateral budget 2006–07	$0.88m

*Includes AusAID-funded projects in Iraq ($0.16m) and Other ($0.01m) (actual 2004–05).
**Includes AusAID-funded projects in Iraq: $0.33m (forecast 2005–06).

Medium-term strategy and priorities

In these other South Asian countries, ACIAR currently supports one active project in each of Nepal, Sri Lanka and Bhutan. One multilateral project commenced in 2002–03 in Afghanistan, and a second phase of this project commenced in 2004. ACIAR is not considering proposals for new projects in Nepal or Sri Lanka in 2006–07. In Bhutan, only proposals for new projects that are initiated and strongly endorsed at an early stage by the Bhutan Government and that closely fit Australia's skills and expertise will be considered in 2006-07. ACIAR is managing two projects in Iraq, co-funded by AusAID. It is anticipated that support will be limited to these two projects and the short to medium term (under three years) as Iraq passes through a critical period of development.

ACIAR provides both core and project-specific funds to ICARDA (International Center 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 larger of the two ACIAR-supported projects in Iraq.

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

Key performance indicators (2006–07)

- At least five Iraqi scientists receive in-depth training in integrated pest management
- CIMMYT wheat lines identified with improved yield and/or disease resistance to local lines in field trials in Afghanistan

[10] Source: United Nations Population Division, 2005, *World Population Prospects: The 2004 Revision*, http://www.un.org/esa/population/publications/WPP2004/World_Population_2004_chart.pdf, composed of Nepal (27.1 million), Sri Lanka (20.7 million), Bhutan (2.2 million), Afghanistan (29.9 million) and Iraq (28.8 million).

[11] Source: United Nations Population Division, 2005, *World Population Prospects: The 2004 Revision*, http://www.un.org/esa/population/publications/WPP2004/World_Population_2004_chart.pdf, composed of Nepal (32.8 / 51.2 million), Sri Lanka (22.3 / 23.6 million), Bhutan (2.7 / 4.4 million), Afghanistan (41.4 / 97.3 million) and Iraq (36.5 / 63.7 million).

Nepal

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).

Sri Lanka

Sri Lanka was an original partner of ACIAR. The high quality of training of many Sri Lankan agricultural scientists facilitated development of the program. Most collaboration has been in animal sciences, especially animal health. Other areas have included fisheries, farming systems economics, agricultural development policy, crop sciences, forestry and crop postharvest technology. Completed projects include an analysis of fisheries management in seasonal reservoirs, an economic study into optimal land use, which developed policies to avoid land degradation in upland plantation areas, as well as a practical model that demonstrated the need to replant/rehabilitate tea plantations to avoid erosion. Several of the outputs are being used in Asian Development Bank-funded projects. Other projects have included economic and simulation modelling of rice-based cropping systems, and a project that successfully attained biological control of *Salvinia* water weed.

The headquarters of the CGIAR centre, the International Water Management Institute (IWMI), are also based in Sri Lanka. ACIAR has a number of past and current collaborative projects with IMWI in India, Pakistan and China.

Bhutan

ACIAR’s small program with Bhutan began in 1998. Because of Australia’s relatively low comparative advantage, the program will remain 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.

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 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.

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 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.

Programmatic emphases in these countries are:

Subprogram 1: Field crop germplasm conservation and improvement

Subprogram 2: Horticulture, including pest and disease management

Key program managers

Mr John Cullen, Crop Improvement and Management
Mr Les Baxter, Horticulture

Country Manager

Dr Kuhu Chatterjee, ACIAR Regional Manager, South Asia (for Bhutan, Nepal, Sri Lanka)

Active projects

1 July 2005 – 30 June 2006

India Bilateral

India Multilateral

India

Bilateral

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

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
Project Web Site	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 30/06/2007 (Project extended from 01/01/2006 to 30/06/2007)
ACIAR Research Program Manager	Dr Ray Trewin

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 and quality.

Project progress

The latest Annual Report is forthcoming. The previous year's has been included for information.

Year 3 (01/01/2004-31/12/2004)

Implementation of the project commenced on 1 April 2002. Despite the delayed start, the proposed work program for the three-year implementation period has been successfully completed. The main tasks accomplished so far included: (a) the literature survey; (b) analysis of trends and patterns of process food exports from developing countries and the WTO mechanism for monitoring food safety standards; (c) and the institutional mechanisms and procedures for meeting food safety standards in India and Thailand; (d) case studies of the selected food industries and firm-level surveys in the two countries; (e) preliminary drafts of the country reports.

The main focus of the Indian and Thai research teams during the period under review (April 2003 – March 2004) was on analysing data gathered from the firm-level survey and drafting the country reports. The team leader and the main co-researcher of each team visited ANU during the year to discuss the preliminary draft of the report with the Australian team and the complete draft is to be submitted by the first week of June 2005. The Indian team has surveyed 71 firms. These include firms in the following industries: shrimp (57) mango pulp (7), egg powder (3) and mushroom (4) industries in the states of Kerala, Tamilnadu, Andra Pradesh, Chandigar and Maharashtra. The Thai team has surveyed 55 firms – Shrimp (40), canned tuna (8) and vegetable (7). (Note that our aim was to survey a minimum of 50 firms in each country.)

The Australian team was involved in writing/finalizing the background chapter for the synthesis volume, which contains three main sections: (1) international food safety regulation and process food exports from developing countries, (2) causes and incidence of detention of processed food imports (based on data compiled from administrative records of the US Food and Drugs Administration), and (3) economics of food safety regulation and trade. The project leader (Athukorala) and the leader of the Melbourne University team (Jayasuriya) made field visits to Thailand (one week) and India (two weeks) in September 2004 to monitor fieldwork and data processing.

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

Overseas Collaborating Countries	India
Commissioned Organisation	La Trobe University, School of Business, Australia
Project Leader	Dr Lin Crase Phone: (02) 6058-3834 Fax: (02) 6058-3833 Email: l.crase@latrobe.edu.au
Collaborating Institutions	Indian Institute of Management, India University of South Australia, Australia
Project Budget	$341,799
Project Duration	01/07/2002 to 30/06/2006 (Project extended from 01/07/2005 to 30/06/2006)
ACIAR Research Program Manager	Dr Ray Trewin

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 in need of 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

The latest Annual Report is forthcoming. The previous year's has been included for information.

Year 3 (01/07/2004-30/06/2005)

Work for the project commenced in earnest in February 2003. In the first reporting period (concluding 1 July 2003) two main activities were reported. Namely:

- The development of an assessment framework for analysing water institutions in a variety of contexts.
- Putting in place the arrangements to conduct the project-initiating international workshop to review and refine the proffered framework.

In the second reporting period the project focussed on five main areas:

- The refinements and extension of the theoretical elements of the institutional framework following scrutiny by participants at the initial international workshop.
- Selection and case analysis of 16 institutional scenarios in India covering ground water, check dams, co-operatives and water user associations.
- The development of statistically robust items for measuring the perceptions of irrigators as they pertain to the main elements of water institutions.
- Development of a survey instrument for making comparisons between water institutions in India and Australia
- Undertaking field work in India in Jan 2004 in Mesahana District looking at the legal elements of groundwater and those rules evolved by the local communities for the operation of shared wells.

In this reporting period five main tasks were undertaken. Namely:

- Deriving observations and lessons from the case studies conducted earlier
- Designing and refining the major survey instruments for primary field data collection in India
- Identification of survey locations, development of sampling frame
- Field work for collection of institutional data from the different survey areas
- Data collection on the legal dimension of Indian water institutions

To date, an expansive institutional and farmer survey has been administered in Andhra Pradesh and Maharashtra covering a range of water institutions and drawing data from hundreds of farms. However, the survey work has been delayed in Gujarat due to heavy rains. This component of the work is expected to be completed by the end of September 2005.

In addition to the institutional and farmer surveys, another instrument gauging the legal dimensions to water management has been administered in Mula Canal, Wahdad. Over 400 interviews were conducted at the first two sites using professional interviewers and translators. An additional site is yet to be surveyed.

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

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 31/12/2007
ACIAR Research Program Manager	Dr Ray Trewin

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, and
- develop and disseminate a set of policy recommendations for more efficient markets to key stakeholders.

Project progress

Year 1 (01/01/2005-31/12/2005)

The Project start was delayed several months due to delays associated with Indian government approval. However, once approval was given the project was initiated with a survey of the relevant Indian and international literature. An Advisory Committee was formed comprising researchers and government officials: Ms. Jyoti Gujral, IDFC; Mr. P.K. Agarwal, Joint Secretary, Ministry of Agriculture, GOI; Professor Mruthyunjaya, NATP; Mr. Bharat Desai, Reliance Industries Limited; Mr. Ishwar Singh Dagar, Government of National Capital Territory (NCT) of Delhi; Mr. R. Gopalan, Mr. R. Gopalan, Joint Secretary, Ministry of Commerce,GOI; Professor Susan Thomas, Indira Gandhi Institute of Development Research (IGIDR). A Project Implementation workshop and and an Advisory Committee meeting were held in May 13 2005 at NCAER in Delhi. The preliminary findings from the literature review and initial general equilibrium analysis were presented.

In line with comments and suggestions made at the workshop, it was decided to focus the research on the following sectors: rice, wheat, cotton and pulses (tur/arhar, and possibly groundnut). A detailed research programme was developed and further consolidated during a visit by Dr Chadha, Indian Team Leader, to Melbourne in July, 2005.

This programme comprises the following activities:

1. An analysis of the market system constraints in the identified agricultural sectors and their impact on prices, production, consumption, trade and efficiency, including field surveys of far-households, traders and government officials involved in selected markets in the states of Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal.
2. Commission study on experience of market reforms – selected markets – by Susan Thomas, IGIDR
3. Commission study of Australian experience with possible implications for India by Scott Davenport, NSW Department of Primary Industry
4. Implement an econometric study of market integration within India and Indian states and world markets
5. Extension of STE models developed by MacLaren and McCorriston to incorporate specific characteristics of selected markets in India (drawing on literature as well as field surveys)
6. Extend CGE model, use STE model estimates and explore impact of policy reforms

At end of December 2005, all identified outputs in project document had been achieved. But due to delayed start several activities – projected to go on for some time through 2006 - may require some additional time than indicated in project documents for completion.

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

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	$693,392
Project Duration	01/01/2003 to 30/11/2006 (Project extended from 01/01/2006 to 30/11/2006)
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 3 (01/01/2005-31/12/2005)

A nutrition trial was conducted in Bangalore, India to evaluate the impact of a fungus-utilising nutrient (mercaptopropanesulfonic acid, MPS) on rumen function and digestion within cattle. Increased utilisation of ammonia-N and elevated VFAs in the rumen of MPS supplemented group demonstrated improved rumen function and increased microbial protein synthesis. A complimentary trial in Australia also showed that MPS increased microbial protein supply to the animal for production. Rumen fungal counts were also higher in sulfur supplemented animals. Higher fungal counts and low NH3–N values in MPS supplemented group complement increased fibre utilization, leading to a better availability of energy from poor quality crop residues and increased utilization of nitrogen in the rumen.

A fungal dosing trial was performed in Australia under tropical animal production conditions. When five elite fungal strains were introduced in the rumen of cattle a significant increase in feed intake was observed for all treated animals. This indicated a greater rate of fibre breakdown within the rumen due to the introduced fungal strains. Additional rumen fungal isolates have been characterised from Indian Buffalo and cattle samples. These isolates have been further characterised for their fibre degrading capability, in which several isolates have been marked as candidates for cattle fungal dosing trials in India. Animal trials in India will move to focussing on the milk production response which is likely to be enhanced from increased flow of microbial protein to the animal.

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

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 used 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, the main pasture plants are usually hard to digest and extract nutrients from.

Considerable benefits 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 absorbed in the intestine. This is termed protective nutrient technology. The nutrient supplements should be readily producible from easily available agricultural by-products.

The project is establishing this, and testing the protective technology, in Indian conditions, to convert readily available agricultural by-products into useful feeds able to survive passage through the rumen and thereby improve ruminant nutrition.

Project progress

The latest Annual Report is forthcoming. The previous year's has been included for information.

Year 5 (01/01/2004-31/12/2004)

The project was due for completion in June 2004. An extension request for the project was made in July/August 2004 to monitor progress at the Itola plant and for the construction of an additional plant, together with further R&D.

A project extension document was developed in conjunction with the National Dairy Development Board, India (NDDB), there were delays in progressing this proposal in India and Australia. The sign off on the project document in India and Australia was completed in April/May 2005 with funds transferred to the University of Sydney in June 2005. An extension in time for the project was sought by NDDB and the University of Sydney. ACIAR has granted the extension in time and the project activity has been extended to June 2006.

Objective 1. Maximize production, monitor maintenance and safety aspects of the by-pass protein unit at the cattle feed plant at Itola, Gujarat, India.

Production per month in May/June 2004 approached 400 MT per month of pellets containing the by-pass protein. Quality control of feed supplements was monitored. All supplements manufactured were within specification with a protein by-pass content of 70-75%

Objective 2. Transfer the by-pass protein technology to village farmers in Gujarat State.

Education and extension activities at the village level are on-going and this has resulted in an increase in use of these supplements by farmers at the village level

Objective 3. Economic evaluation of the feeding trials in the Baroda district.

A report was completed and provided to ACIAR on the socio-economic analysis on the use of by-pass protein at the village level was undertaken by Professor George from the Centre for Centre for Development Studies, Thiruvanthapuram, Kerala, India. The economic impacts at the village level were greatest for farmers milking buffaloes followed by local cows and crossbred cows, with a net additional income of Rs 7.28 to 12.41 per animal per day.

Objective 4. Prepare reports, publications and other publicity material.

A list of publications and publicity is provided separately.

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

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 30/06/2007 (Project extended from 01/07/2005 to 30/06/2007)
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 A$10 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 A$1 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 4 (01/07/2005-30/06/2006)

In 2006 the TDS situation in Tamil Nadu (TN) has become even more critical for the tanning industry than it was in 2005. The Erode Court Ruling of 2005 now applies to all of Tamil Nadu. Tanneries not discharging to a CETP must meet 2,100 ppm TDS or install Reverse Osmosis (RO) at high capital, operating and maintenance costs. By the end of 2007, CETPs must meet 2,100 ppm TDS or have zero effluent discharge which will again mean installation of RO. This means that all TN tanneries or their CETPs require RO. RO concentrates will be solar evaporated.

Tanneries in Erode have installed RO but those in wet-blue plants are not yet operational. A number of larger TN tanneries processing hides and skins from wet-blue to finished leather have found that the use of the low salt permeate from RO for processing provides considerable chemical savings in dyes and other expensive chemicals, due to the low TDS. These savings offset costs. In wet-blue plants there are no chemical savings and it is anticipated that there will be problems with RO membrane fouling in wet- blue tanneries, except for goat skins when the hair is saved.

A recent audit has found that most Erode tanneries 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.

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.

Hide and skin preservation
Low salt preservation
To reduce TDS, first handlers of Indian goat skins will salt unopened skins as usual 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 was a problem with the flesh sides of the skins sticking together. In summer this was a major problem because the sticking made opening up of the skins very difficult. After further CLRI laboratory trials, the tannery collaborating on the low salt system has now achieved a good result with skins preserved with 20% salt and 2% sodium carbonate and held for over 3 weeks in hot summer conditions. The 50 treated skins were more moist than the control skins but they were well preserved and could easily be turned flesh out and opened. A trial with 500 skins is now planned.

An Australian skin merchant and a major woolskin processor collaborated with CSIRO in a successful, one year commercial trial of flat salting with low salt levels and sodium fluoride plus boric acid as additives. Very unfortunately the woolskin processor, which was under pressure to reduce TDS, closed Australian operations in December 2005. There are now no large woolskin tanneries in Australia and most skins are conventionally drum salted and exported to China. The skin merchant does not have a market for the flat salted skins as they require more labour to produce and are therefore slightly more expensive.

It is very difficult for Australian tanneries to compete with China and unfortunately the other Australian tannery collaborator also closed at the end of 2005. The pickle liquor and chrome liquor recycling systems had been very successful in reducing effluent TDS.

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

The CLRI mobile chilling unit has now been used for three industry trials. All the trials in Kerala and Erode have been very successful with wet blue quality being assessed as no different to usual production. KKSK, the largest hide tannery in Erode, has done 2 trials and is very impressed with chilling. KKSK sees that eventually all Erode tanners will use chilling. At the Erode workshop in July 2006, 6 more tanners signed up to do trials with the mobile chiller. Full implementation of chilling by KKSK is being investigated.

Direct Chrome Liquor Recycling (DCLR)
Commercial trials at 4 tanneries have been successful. No tanneries have yet implemented the process but now that chrome prices have increased and TDS discharge is more critical, the benefits have increased and several tanneries are planning implementation or scaling up trials.

Pickle Liquor Recycle (PLR)
One Dindigul tannery which used to discharges pickle liquor after each use has successfully adopted the system for regular processing. The tanner is demonstrating the system to other tanners. Two other tanneries have done trials but have not yet implemented the system.

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

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 field 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 Maharashtra.

Project progress

Year 3 (01/01/2005-31/12/2005)

Objective A: Production of appropriate genotypes for testing in shepherds' flocks (India).
The breeding program at NARI is now based on a selection index based on estimated breeding values and economic values for 4 traits namely three-month weight, fertility, litter size and lamb survival. Using the index some 25% of mature ewes were culled during the year (161/660). Matings for 2006 will be designed using the TGRM software.

In Feb-March 2005 297 lambs were born at NARI from an AI program in Sept-October 2004. From 94 FecBB+ ewes inseminated, 102 live lambs were produced (109% lambing) and 96 lambs reached 3 months of age (102% weaning). From 247 FecB++ ewes inseminated, 195 live lambs were produced (79% lambing) and 190 lambs reached 3 months of age (77% weaning). Overall lamb mortality to 3 months was 3.7% which is very low.

Two further AI programs took place at NARI during 1995. In Feb-March 2005 213 ewes were inseminated producing 190 lambs born and 172 lambs reared to 3 months. Overall lamb mortality of 9% was moderate. Lambing % for FecBBB (n=4), FecBB+ (n=93) and FecB++ (n=116), ewes respectively was 100%, 100% and 80%. Weaning % (to 3 months of age) was 100%, 88% and 75% respectively. A further 258 ewes were inseminated in September October and these will lamb in Feb 2006. A total of 487 lambs was born during the year of which 70 were FecBBB, 315 were FecBB+ 102 were FecB++. It is pleasing that 79% of all lambs born contained the FecB mutation. Lamb mortality to 6 months of age was a relatively high 20% due to an outbreak of bluetongue disease in the district. By comparison mortality in 2004 was 9%.

Total sheep numbers at NARI at the end of 2005 were 845. Amongst the crossbred ewe population there are 14 FecBBB, 111 FecBB+ and 93 FecB++ ewes available for breeding in February 2006. During the year 354 DNA samples from NARI and 155 from shepherds' flocks were genotyped for the FecB mutation at NCL.

Objective B: Testing of improved genotypes in shepherds' flocks and development of appropriate management technologies.

To date 60 FecBBB+ and 60 FecBB++ ewes have been distributed to 22 smallholders from NARI. In addition 20 AI programs using semen from rams carrying the FecB gene have been carried out and multiple ram introductions made using NARI rams carrying the FecB mutation. Currently there are 21 smallholders with 1200 breeding ewes involved in this objective. Data from the 2004 and 2005 lambings of distributed ewes indicate that one copy of the FecB mutation confers an additional 0.3 lamb per ewe born and 0.14 additional lambs reared to 6 months of age.

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

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(bus), tsetter@tpgi.com.au (home)
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	$922,361
Project Duration	01/01/2001 to 31/12/2006 (Project extended from 01/01/2005 to 31/12/2006)
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. Because of this large genetic variation, improving the tolerance of crops to water-logging offers considerable potential for success. 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 10mm additional rainfall in August in one district of WA, productivity fell by about 150kg of wheat per hectare.

A few water-logging-tolerant cultivars of wheat are known. This project is conduct determining the mechanisms of tolerance in wheat, and to produce tolerant breeding lines by pooling traits in suitable germplasm for use in both countries. The aim is to produce breeding lines of wheat for Australia and India that are tolerant of water-logging in the main soil types in which this occurs in these two countries.

Project progress

Year 5 (01/01/2005-31/12/2005)

Research on waterlogging tolerance of wheat for 2005 was completed successfully, resulting in the compilation of data for the Final Review held at the Central Soil Salinity Research Institute (CSSRI), Karnal, India, over March 6-8, 2006. Research covered in this period consists of 1) concluding research from the final six months (January 1 to June 30, 2005) on Project CS1/1996/025, and 2) the first six months research (July 1 to December 31, 2005) on the "12 Month Project Extension to ACIAR Project CS1/1996/025 on Waterlogging Tolerance of Wheat" (Project CMS/1996/025).

During 2005 there were no funds for continued work from UWA (whose final project achievements are summarised in the ACIAR Annual Report 2004 - Project CS1/1996/025). There were also no funds available for project staff at the Department of Agriculture and Food Western Australia (DAFWA). Therefore only a limited research program was followed in Australia primarily aimed at (i) supervising collaboration in India; (ii) extending screening methods to segregating bulk DH populations; and (ii) multiplying seed (approximately 1440 genetically fixed breeding lines) for distribution to Indian partners in 2006.

Good progress has been made during 2005 on all five objectives for the first 6 months of ACIAR Project CIM/1996/025 by both Australian and Indian partners. These project extension objectives are:

1. Develop new methods to screen DH and segregating populations as bulks.
2. Continue the development of new DH lines/populations.
3. Continue evaluation of adaptive physiological traits for waterlogging tolerance.
4. Evaluate waterlogging tolerance at the germination stage (results not presented in this first 6 mo. report)
5) Multiply seed of the available 10 DH populations for waterlogging tolerance.

Due to the 6 month delay in field season for India, results from the 12 Month Extension will only be provided here from DAFWA, while results from India will be included in the Final Report.

New methods using soil bins have been used to screen bulk DH and segregating populations in different soils in WA (DAFWA). Similar approaches have been successfully evaluated in the field in India by all Indian partners (not reported here). This now extends screening protocols originally developed for varieties and genetically fixed lines to populations with an increase in screening speed of up to 100 times. The impact of this method is that now germplasm evaluation can keep pace with germplasm development. Furthermore, breeders can screen non destructively and make selections at any stage of germplasm development.

New DH lines/populations have been developed for four populations in 2005: Tammarin Rock / EGA-Bonnie Rock (~300 lines; these parents are extremes in waterlogging tolerance in Katanning soil), EGA-Bonnie Rock/Tammarin Rock (~300 lines), Chara/Camm (~200 lines; these parents show extremes in waterlogging tolerance at germination stage; Setter and Waters, 2003) and KRL35/Tammarin Rock (~200 lines).

In 2005, a small nursery was also established based on varieties and near-isogenic lines differing in tolerance to microelements. The evaluation of these genotypes in target environments where waterlogging occurs will enable determination of whether microelement toxicities are exacerbated under waterlogging in specific soils. This has been confirmed in preliminary observations. The current hypothesis is therefore supported that waterlogging adversely affects plant growth by a product of both anaerobiosis and microelement toxicities (Khabaz-Saberi et al., 2006; Setter, 2006).

Bulking seed supplies was also completed in this period. Approximately 1500 DH lines and varieties were bulked as genetic resources (25-100 g/line) for distribution to Indian partners in 2006.

A summary of achievements and impacts of project work highlighting research from 2005 was prepared for the Final Review (Setter, 2006) and this is available as a pdf file from Dr. T. Setter (tsetter@agric.wa.gov.au) and attached to the electronic copy of this report. Detailed research work is now under preparation for publication for a major review on germplasm improvement for waterlogging tolerance and for separate research papers on soil science, physiology, and breeding for waterlogging tolerance.

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

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: psalisburt@optushome.com.au, 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, and
- developing and providing appropriate information on improved germplasm and disease epidemiology for incorporation into existing technology transfer protocols.

Project progress

Year 2 (01/01/2005-31/12/2005)

Significant progress was made during 2005 to identify variability for key agronomic, quality and disease resistance characters through the use of screening protocols. The first exchange of germplasm of B. napus and B. juncea between Indian, China and Australia was completed by mid 2005 to allow sowing of field trials in the 2005/06 season. The material to be assessed in each country for the key characters consists of, B. napus: 25 Australian, 20 Chinese and 3 Indian lines and B. juncea: 22 Indian, 12 Australian and 10 Chinese lines. In Australia the field trials were sown in Vic, NSW, SA and WA and were harvested at the end of 2005. The data from these trials will be analysed in early 2006. In China the germplasm was sown at two sites in Wuhan in Sep/Oct 2005 and the key characters are currently being assessed. In India the germplasm was sown in Oct/Nov 2005 and to date emergence, early vigour and initiation of flowering data have been recorded. Results from a preliminary screening of Australian and Indian germplasm in India in the 2004/05 season indicated that there is substantial variability in key characters including date of emergence, seedling vigour, white rust incidence, oil and glucosinolate content and fatty acid composition. Screening and characterisation of B. juncea and B. napus for seedling stage thermotolerance and terminal stage heat tolerance is underway in the field and laboratory at Haryana Agricultural University, Punjab and Punjab Agricultural University, India. Drought tolerance screening is also underway at HAU. Screening of germplasm for Sclerotinia was also initiated in 2005 at HAU, India and UWA, Australia. In Australia it was observed that most B. juncea germplasm was highly susceptible to Sclerotinia, based on the length of stem lesions, although there were some more resistant lines from Australia and China. Significant differences for white rust resistance between Australian B. juncea lines were also observed in WA.

During 2005 activities were initiated to enhance the germplasm in all countries for key characters through selection and breeding. At PAU, India interspecific hybridisation between B. napus and B. carinata / B. juncea was undertaken and desirable F2/BC1 plants from both the crosses will be backcrossed with selected Australian B. napus lines. At Haryana Agricultural University, Punjab, 40 crosses have been made between Indian and Australian lines of B. juncea, and 60 crosses between Australian and Indian lines of B. napus are also being attempted this season. At TERI, India shattering tolerant B. napus lines (developed at TERI) have been sown and will be crossed with the Australian lines to transfer shatter tolerance. In NSW, Australia, 21 crosses were made between Sclerotinia tolerant Chinese lines and elite Australian lines and further crossing will be done in 2006.

Progress was made in 2005 towards the identification of genetic distance and heterotic pools. At UWA, useful SSR markers were identified on all chromosomes for estimation of genetic distance among B. napus lines from Australia, China and India, and selfing and purification of these lines began for future genetic studies. At Huazhong Agricultural University, China a preliminary experiment was conducted to assess marker techniques for genetic diversity analysis. Results indicated that SRAP (sequence-related amplified polymorphism) are distributed on all 19 chromosomes of B. napus more equally than AFLP and the technique is more efficient than SSR, so SRAP and SSR markers will be used to evaluate the genetic diversity of all B. napus and B. juncea lines. At Punjab Agricultural University, India DNA isolation from all the B. juncea genotypes has also been completed.

During 2005 significant progress was made towards the objective of increasing the scientific skills of scientists collaborating in the project through scientific exchanges. Dr Abha Agnihotri, Dr Dhiraj Singh and Dr Surinder Banga visited Australia in 2005 for a scientific interaction/study program. The program included 3 days of NIR training at Wagga Wagga Research Institute, visits to Brassica trials in NSW, Victoria and SA, meetings with scientists at CSIRO, Canberra, a meeting with John Cullen and attendance at the Australian Research Assembly on Brassicas (Port Lincoln, SA). Dr Maharaj Singh (NRCRM, Bharatpur) also visited Australia from Sep to Dec 2005 for training. Dr Singh conducted a drought tolerance project supervised by Dr Rob Norton (University of Melbourne) at DPI Horsham. Dr Singh learned to use a range of equipment, visited scientists at CSIRO and ANU Canberra to discuss drought screening and also attended the Australian Research Assembly on Brassicas. Assoc Prof Phil Salisbury and Assoc Prof Martin Barbetti visited India in February 2005 for discussions with project collaborators. In addition, Dr Martin Barbetti and Dr Caixia Li attended the International Sclerotinia Workshop in California in June 2005. Following this workshop, Dr Li visited Huazhong Agricultural University and Wuhan Oil Crops Research Institute, China, where she met with oilseed Brassica scientists working on this ACIAR project, and, in particular, had the opportunity to assess and develop common approaches on study of Scelorotinia disease.

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

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 are dependent on maximising harvested seeds in a humid environment were spoilage is common. Static yields and low prices mean that even small reductions of post harvest losses can translate into significant additional security and income. Storage of surplus grains until periods of shortage when prices are higher only provide 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 small holders. 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 underway. However few smallholders are in a position to adopt this without support, mainly from NGOs.

Local seed processors are well placed to do so 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 progress

Year 3 (01/07/2005-30/06/2006)

During the third year of the project following activities have been carried out:

a) Central Mechanical Engineering Research Institute CMERI team:

The statistics of the annual grain production in West Bengal and the other northeastern states of India (Arunachal Pradesh, Assam, Meghalaya, Mizoram, Tripura, Manipur and Nagaland) have been updated. They included grain and seed production data for paddy, wheat, maize and oilseeds. In West Bengal the total production of paddy rice increased from 14.7 to 15.5 million tonnes whereas the wheat production increased from less than 1 million to more than 1.1 million tonnes between 2003-2004 and 2003-2005. The seed requirement in West Bengal in 2003-04 was 35 thousand tonnes of paddy and 12 thousand tonnes of wheat. In the other northeastern states the demand was 26 thousand tonnes of rice, 41 thousand tonnes of wheat and 5 thousand tonnes of maize seed. Increased demand of seed means increasing demand of mechanical dryers as the safe moisture level

for seed storage, 13% wet basis, cannot be maintained under the prevailing climatic conditions without mechanical drying.

The seed production infrastructure has also been surveyed and it was found that there were seven major seed producers (including over 40 state seed farms). Furthermore, the survey has shown that there were 24 major animal feed producers including state owned enterprises in four of the northern states. There are also more than 400 rice mills in West Bengal alone. Finally, there are four major dryer manufacturers in the region.

As a result of the surveys, contacts have been established with nine major seed producing companies as well as with feed mills interested in improving their drying facilities. An important partner is the West Bengal Dept. of Agriculture and especially the seed farm in Burdwan near Durgapur.

The modelling and design work included as follows:
Determination of thermophysical properties of economically important paddy varieties. They included grain size, density, specific heat, thermal conductivity and sorption isotherms at different temperatures. Mathematical models were fitted to these properties when appropriate. Historical data on temperature, humidity and rainfall have been collected for the representative locations of the following regions:

- Gangetic West Bengal (Kolkata & Burdwan)
- Sub-Himalayan West Bengal (Jalpaiguri)
- North-Eastern States (Guwahati)

Weather data loggers have been placed in the WB Govt. farms at Burdwan, Bankura and Jalpaiguri for current data recording and analysis later on.
The thermophysical properties of grain and the weather data are added to the existing drying simulation package in order to provide a predictive tool for design and optimisation of in-store drying systems.

In addition to this work, the CMERI team has designed and tested a laboratory-scale two-stage drying system consisting of a fluidised bed dryer and an in-store dryer as 1st and 2nd stage dryers respectively. The fluidised-bed dryer can be operated in batch or continuous mode, has a capacity of 20 kg paddy/h and can remove moisture from 30% down to 20% wet basis. It has been tested within 60-90C temperature range. The in-store dryer has a capacity of 0.9 m3 and is using near-ambient air. Drying models have been developed for both dryers.

Full-scale prototypes for both the 1st stage fluidized bed dryer (150 kg/h capacity) and the 2nd stage in-store dryer (4.6 m3 capacity) have been installed and commissioned at Burdwan seed farm of Govt. of West Bengal. Experiments of the two stage drying system with freshly harvested grains are in progress in order to validate the results of the laboratory tests and to demonstrate the system to the users. In addition to research activities, CMERI hosted the 4th Asia Pacific Drying Conference in December 2005 (ADC05) in Kolkata where the principle and applications of the two-stage drying system were demonstrated.

b) Food Science and Technology, University of New South Wales team

Extensive work has been carried out on the modelling of two-stage drying of seed of three major grain crops: rice, wheat and maize. The research work includes the use of fluidised and spouted-bed dryers and of an in-store dryer using near-ambient air. Seed quality attributes such as viability and vigour are included in the model.

A further major research activity is the development of finite elements method (FEM) to describe the drying behaviour of a single kernel. FEM allows to study the following areas:

- Effect of changes in drying conditions
- Fissuring
- Surface ‘melting’ effect at high temperature
- Directional drying

Finally, both teams are developing training tutorials based on the computer assisted learning principle for dissemination of project outputs among the potential users.

CIM/2005/012: Aflatoxin workshop in India

Overseas Collaborating Countries	India
Commissioned Organisation	International Crops Research Institute for the Semi Arid Tropics, India
Project Leader	No details available for project leader
Collaborating Institutions	
Project Budget	$30,000
Project Duration	01/06/2006 to 30/06/2007
ACIAR Research Program Manager	Dr Paul Fox

Project background and objectives

Recommendations for follow-up work arose from two recently completed ACIAR projects: PHT/1997/017 (Reducing aflatoxin in peanuts using agronomic management and bio-control strategies in Indonesia and Australia) and PHT 2000/080 (Selection for peanut varieties with low aflatoxin risk). One recommendation was to support a regional workshop to bring together the outputs of the two projects, and this is planned for the ICRISAT Center in India from Feb 21 to 23, 2007. Participants will be largely from India (ICRISAT and ICAR), Indonesia (ILETRI and BIOTROP) and Australia (QDPIF) but they will use the opportunity to discuss global progress in managing aflatoxin contamination in peanut over the past 20 years (since 1987 when ICRISAT held the original aflatoxin workshop), as well as developing new ideas for future projects.

Project progress

First progress report due in 2007.

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

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 31/12/2006
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 2 (01/01/2005-31/12/2005)

Project research in Australia began formally in July 2004 but was delayed until November 2004 in India. In India, major progress was made with larval rearing of the Giant Freshwater Prawn (GFP), *Macrobrachium rosenbergii*, in saline groundwater at the Central Institute of Fisheries Education (CIFE) Rohtak Centre in the State of Haryana. Saline groundwater (12 ppt) pumped directly from the ground is not suitable for larval rearing of GFP as all larvae died within 5 days after hatching. Analysis of the ionic composition of the inland saline groundwater (ISG) showed that concentrations of potassium and magnesium were much lower and calcium was much higher than those found in the same salinity coastal seawater (CS). Methods were developed to alter the concentration of these ions in ISG to approximate CS concentrations and GFP larvae survived and grew through all 11 larval stages and successfully metamorphosed into post larvae. This represents the first account of successful post larval production of GFP in ISG.

A small-scale commercial GFP hatchery is under construction at the Rohtak Centre to continue replicated experiments and also to produce post larval seed for supply to local growout farms, which are developing in Haryana. Research into development of growout technology of GFP in ISG did not commence as the Spring/Summer of 2005 growing season was missed due to delays in starting the project and severe waterlogging of the research site after the monsoon. Waterlogging prevented the construction of experiment greenhouses and evaporation ponds for disposal of saline groundwater.

In Australia, two experiments in successive winters of 2004/05 (reported earlier) and 2005/06 have been completed to (1) evaluate the performance of rainbow trout in plastic-lined ponds at the ISARC (2) provide production data to allow bio-economic modelling (3) obtain feedback on market acceptance of harvested trout.

Results demonstrate that the saline water pumped directly from the ground at ISARC is suitable for production of rainbow trout and that air and water temperatures are suitable (cool) for approximately 7 months/yr for optimal growth of trout. Harvesting of market-size (300g+) trout commenced in September 2005, 4 months after stocking and continued until December 2005. Approximately 500 kg of fresh trout was sold through retail outlets in the local community of Deniliquin, Barham, Finley and Wakool with excellent market acceptance.

In summer 2004/05 an experiment was conducted to determine the effect of greenhouse covers on growth and survival of kuruma prawns, *P. japonicus*. Six, 2000-L tanks were filled with potassium fortified saline groundwater (35ppt) and each tank was stocked with 150 post-larval prawns (0.1 g average weight). Three tanks were covered with a polysheet and three tanks remained open to ambient environmental conditions. Prawns were fed and managed according to normal pond culture methods. After 131 days, prawns grown in the covered tanks were 7.3 g and twice the weight of prawns grown in uncovered tanks (3.8g). Water temperatures in the covered tanks were 2-5 ^{O}C warmer on average than that in uncovered tanks and was the likely factor contributing to increased growth in covered tanks.

An experiment to evaluate the performance of juvenile mulloway in ponds covered with floating solar covers was initiated in May 2005 however a severe storm soon after stocking destroyed the covers in two ponds. The experiment was terminated while the floating covers were repaired. Mulloway held in uncovered, ambient ponds during winter did not grow but survival was high. The experiment was restarted in November 2005 and will continue until December 2006.

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

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 1 (01/01/2005-31/12/2005)

Objective 1 Reduce the risk of WSD in shrimp farms through the application of PCR-based detection tests and epidemiological probes.

A major experimental component of this project is a large longitudinal study of shrimp ponds in 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. The longitudinal study was conducted at a NACA/MPEDA/ACIAR study area in the West Godavari District of Andhra Pradesh. The site comprises 27 farm clusters around 14 villages between Bhimavarum and the mouth of the Godavari River.

Farmers participating in the study are members of “aquaclubs” formed as part of an ongoing extension program of best management practices. The farms were stocked in February - April 2005 with PCR-screened post-larvae (PLs) obtained from local hatcheries. Some farmers employed nursery ponds to improve survival rates during grow-out. Each nursery pond served to seed a number of grow-out ponds at the same location. A total of 27 nursery ponds were sampled on stocking; 19 of these were also sampled at harvest. A total of 457 grow-out ponds were sampled at the time of stocking. Samples were also collected during disease outbreaks from 14 ponds, emergency harvests from 52 ponds, and planned harvests from 277 ponds. Wild shrimp were collected from 23 ponds and crabs from 65 ponds during the period between stocking and harvest.

The shrimp samples were preserved in alcoholic fixative for subsequent analysis by PCR. Other samples collected from disease outbreaks and emergency harvest ponds were preserved in Davidson’s fixative for histological analysis. All samples were transported to CIBA in Chennai and catalogued. Samples for PCR analysis were divided into two equivalent sets. Testing of samples in the first set will be conducted at CIBA and the College of Fisheries in Mangalore. The second set of samples will be transported to CSIRO in Australia. All histology samples were retained for preliminary analysis at CIBA. Laboratory analyses on all of these samples will be reported during the next period.

Objective 2 Reduce the risk of yellow head and other diseases in shrimp farms through the application of PCR-based detection tests and epidemiological probes.

Monodon slow growth syndrome (MSGS) is a newly emerging disease that has impacted severely on *P. monodon* production in Thailand with losses in 2004 estimated at ~40 million baht. Work at Centex Shrimp in Thailand has suggested that the disease is infectious. Examination of shrimp displaying signs of the disease has identified three infectious agents – a yellow head virus genotype, a new shrimp virus (Laem Singh virus - LSNV) and a microsporidium. It is not yet clear which, if any, of these agents is the primary cause of MSGS. LSNV has been partially sequenced and a PCR detection test developed. Using this test, the virus can be detected in healthy shrimp as well as those showing signs of slow growth. In June-July 2005, Dr Sitidilokratna of Centex Shrimp visited CSIRO to apply the PCR detection test to *P. monodon* samples from throughout the Indo-Pacific region. LSNV was detected in shrimp from Thailand, Malaysia and Indonesia but not in samples from Australia, India, Vietnam, Mozambique or Fiji.

Objective 3 Improve the effectiveness of PCR-based viral screening in hatcheries and service laboratories in India. Indonesia and other countries in the Asian region.
The project also aims to enhance technical capabilities in India and Indonesia through PCR training workshops and the inter-calibration of PCR testing performance between laboratories. The first PCR training workshop was held in Bogor, Indonesia in August 2005. The workshop was attended by 24 participants from laboratories throughout the Indonesian archipelago. A second PCR training workshop was held at CIBA in India in October 2005 with financial support from MPEDA. The workshop was attended by 25 participants from hatcheries and government, private and research laboratories in seven States, and 3 international participants (Sri Lanka, Bangaldesh and Myanmar) supported by ACIAR. Each workshop included practical sessions and an open Seminars which were attended by representatives from the research, government and industry sectors.

Mr Agus Sunarto and Mrs Isti Koesharyani from the Fish Health Research Laboratory, Jakarta, and Mrs Christina Handayani from the Center for Brackishwater Aquaculture Development, Japara, Indonesia visited AAHL in July 2005. These scientists assisted with preparation for the training workshop in Bogor and participated as trainers in the workshop. They were also instructed in the use of real-time PCR during the visit to AAHL. Dr Nursa Sittidilokratna of Centex Shrimp, Thailand visited AAHL in June-July 2005 to work with CSIRO staff on studies of LSV. Dr Sitidilokratna also advised on the implementation of training workshops and participated as a trainer.

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

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 progress

Year 3 (01/01/2005-31/12/2005)

Sikkim's first semi-commercial citrus nursery facility became operational during 2005 as a direct consequence of the project. While primarily intended for propagating trees for the various experiments in the project, the Sikkim collaborators were eager to see the facility providing budded trees to local farmers. This has never happen in Sikkim before as all trees supplied to farmers have only been seedlings, which take more than 7 years to start fruiting where as budded trees fruit within 3 years. Experimental trees budded in 2004 were successfully maintained at the Linjok nursery facility and during 2005 reached sufficient size to be ready for field planting. Trees in the budwood-source-experiment were maintained in near-insect-proof conditions and treated with systemic insecticide to reduce chances of changing disease status during the nursery phase. Diagnostic samples were collected from these trees just prior to field planting to ensure that their disease status had remained the same as the original source material.

Visits to commercial citrus orchards in Sikkim in late 2005 further demonstrated the devastating nature of Huanglongbing disease, its long-term socio-economic impacts, and the need for real scientific solutions rather than workshops and training sessions which raise expectations but can offer no means of addressing the disease impacts. The project team re-visited an orchard that had been inspected in 2003, at which time there had been clear signs of disease, but the orchard was still productive and the farmer was proudly photographed in front of her best tree. Arriving at the property in 2005, all trees were unproductive and the once prosperous farmer now dejected and facing economic ruin. The training course that the farmer had attended at the National Citrus Centre during the intervening period had done nothing to avert the impending disaster. It is only from technology developed in research project like this one that there may be an opportunity for successful citrus production in Huanglongbing endemic areas.

In Australia, a Eureka lemon rootstock experiment established to identify improved genetics for subtropical lemon production has produced substantial quantities of fruit despite the young age of the trees. These fruit were subject to detailed assessment to determine what effect rootstock has on commercially important quality traits. In the absence of diseases like Huanglongbing, yield is seldom a limitation in subtropical citrus production and it is factors like fruit size, juice content and skin texture that affect the marketability and profitability of lemon growing. Australian lemons are often seen as poor quality on the international market. The rootstock experiment established in this project is beginning to reveal opportunities to increase the market attractiveness of Australian lemons.

With more than 30 different varieties, the Imperial rootstock experiment established by this project represents the most diverse range of germplasm ever tested under mandarins in Australia. Imperial is the main domestic mandarin variety and the vast majority of production occurs in the subtropics. Previous work by the project team has demonstrated the potential of rootstock genotype to overcome some of the quality problems associated with Imperial mandarin, and this new experiment made possible by the ACIAR project is building on this experience. Trees are now well established in the field and will produce their first crop of fruit in 2007. However, the work has made some important discoveries even before fruit production commences. The experiment was designed to incorporate germplasm that has performed well in recent overseas research, and as such the citrange variety ‘Savage’ was included. However our experiment has discovered within 12 months of field planting that ‘Savage’ is highly susceptible to local strains of Citrus Tristeza Virus and Imperial trees on this rootstock show severe stem pitting, stunting and tree death. Such results demonstrate the commercial importance of testing germplasm under local disease conditions, a philosophy which has been central to project work in both Sikkim and Australia.

Citrus canker disease has resulted in the recent destruction of more than half a million citrus trees in commercial orchards in an attempt to eradicate the disease from Australia. Research work from this ACIAR project has aided this campaign by providing crucial information on the susceptibility of native Rutaceae species to the disease. Without such information native species may unknowingly harbour the disease and act as a source of re-infection. The ability of project members to work effectively as a team and bring together a range of diverse expertise enabled the project to address the interaction between pathogen, host and disease development. This information was then utilised in the eradication campaign to target susceptible species.

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

Overseas Collaborating Countries	China, India
Commissioned Organisation	Centre for International Economics, Australia
Project Leader	Dr Andrew Stoeckel Phone: (02) 6245 7800 Fax: (02) 6245 7888 Email: astoeckel@thecie.com.au
Collaborating Institutions	
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 progress

First progress report due in 2007.

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

Overseas Collaborating Countries	India
Commissioned Organisation	CSIRO Land and Water, Australia
Project Leader	Dr Elizabeth Humphreys Phone: 0400 601 528 Email: Liz.Humphreys@hotmail.com
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 progress

Year 4 (01/01/2005-31/12/2005)

Sub-project 2. Field evaluation of permanent bed and conventional RW/rice-based cropping systems in Punjab/NSW

India
Field experiments on a sandy loam and a loam soil were continued with the 3rd wheat crop (5thcrop) in 2004/5 followed by the 3rdrice crop in 2005. As in previous years, grain yields of wheat on both fresh and permanent beds were around 20% and 10% lower than yields with conventional tillage on the sandy loam and loam soils, respectively. Yields on fresh and permanent beds have been comparable to date, suggesting no significant effects of “aging” of the beds to date, and there is no trend for decline in relative wheat yield with time on the permanent beds. We need to look at methods of increasing leaf area faster to identify whether this is a causal factor, using methods such as earlier sowing (not possible if we continue with direct seeded rice in the rotation) or increasing the number of rows on the beds.

Yields of both transplanted and direct seeded rice on beds have continued to decline as the beds age relative to continuously flooded puddled transplanted rice (PTR-CF) – to very low values of about 40% and 20% of PTR-CF in 2005. The problem of iron deficiency in direct seeded rice and beds is getting worse with time, despite daily irrigation for the first 6 weeks and application of 15 t/ha of farmyard manure prior to sowing to increase soil organic C and try create more reducing conditions. Causes of the continuing decline with transplanted rice on beds are unknown.

Monitoring of the dry down of the soil after the last irrigation of rice in 2005 showed that drainage continued out of the profile (0-1.8 m) for about 4 weeks. By the time of wheat sowing, the profile was only about half full on both soil types. The results show the free draining nature of these soils, and have implications for accurate determination of the water balance of individual crops and the total cropping system. In farmer-size fields (~0.5 acre), yields of transplanted rice on fresh beds were about 10% lower than PTR-CF, with less than half the amount of irrigation water.

Australia
In Australia, establishment of rice on beds and bed shoulders was excellent using the Stubble King seeder with parallelogram disc assemblies, however, extremely cold conditions during early pollen microspore resulted in 41-65% floret sterility, bringing yields down to 6.1 t/ha on the beds which were ponded between panicle initiation and anthesis, and 3.5 t/ha on the non-ponded beds (compared with the Coleambally district yield of 5.7 t/ha). Yield and input (I+R) water productivity of soybeans on beds were slightly higher with sub-surface drip irrigation (3.3 t/ha, 0.60 t/ML) compared with furrow irrigation (3.1 t/ha, 0.54 t/ML). Establishment and growth of wheat sown in May 2005 were similar on beds and flats up to anthesis.

In October 2005, all treatments except those with wheat in 2005 were sown to rice, with 4 N rate sub-plots, to compare performance for the rice-based system intercropped with barley and soybeans versus a rice-fallow system on beds, and the rice-fallow-wheat-fallow-rice on flats and beds.

Sub-project 3. Maize-wheat and soybean-wheat systems in Punjab

Field experiments were continued with the 3rd wheat crop (6thcrop) in 2004/5, followed by the 4thmaize and soybean crops in 2005. As in previous years, growth and yield were similar for all treatments – fresh and permanent beds, conventional tillage and direct drilling on the flat. Irrigation applications were always lower on the beds (by design), resulting in higher irrigation water productivities on beds, presumably due to greater deep drainage losses on the flats. Preliminary results indicate deep drainage below 2 m in both beds and flats associated with irrigation. Evaluation in farmer-size fields is needed for realistic determination of components of the water balance because of the short irrigation time (a few minutes) and reduced opportunity for deep drainage losses in small plots compared with large fields (a few hours).

The comparable performance of wheat on beds and flats in this sub-project continues to be in contrast with the findings in the rice-wheat systems in both sub-projects 2 and 4. This suggests that the difference may be associated with the long history of rice in the rotation (>20 years) in the rice-wheat systems, in comparison with the loamy sand which has never grown rice. This needs further investigation.

Sub-project 4. Nitrogen use efficiency in RW cropping systems in Punjab (with IAEA)

Field experiments continued with the 3rd wheat crop followed b the 4th rice crop. As in sub-project 2, rice yields continued to decline on the permanent beds with both transplanted and direct seeded rice, relative to the puddled transplanted control with the same irrigation scheduling. Mulching had no effect on transplanted rice yields on beds, but reduced growth and yield of direct seeded rice on beds as in previous years. Iron deficiency and nematodes were again serious problems for direct seeded rice. As in sub-project 2, yields of wheat on permanent beds have been consistently lower than yields of conventionally tilled wheat on the flat, but with no declining trend as the beds age. After 7 crops with mulching, soil organic C at 0-15 cm has increased significantly by 0.6-0.7 g/kg or 12-13%.

Sub-project 5. Modelling to identify management options for maximizing the productivity of RW cropping systems

CSM-CERES-Rice predicted maturity and grain yield of puddled transplanted rice on the flat in our ACIAR experiments (India) reasonably well. Agreement between predicted and observed values on the beds was much poorer, which is not surprising given the many non-modelled factors that appear to be reducing rice yields on the beds. CSM-CERES-Rice currently does not have the capability to automatically schedule irrigations according to the duration of the non-ponded period after the floodwater has gone – the recommended practise in NW India is to irrigate 2-3 days after flooding has ceased. We are currently programming this capability into the model, to allow realistic scenario analyses using historic (30 years) weather data.

CSM-CERES-Wheat predicted yield of wheat on both flats and beds reasonably well for our ACIAR experiments in India. However, it does not have the capability of automatic irrigation based on cumulative net ET (ETrain) or growth stage. Irrigation scheduling guidelines for wheat in NW India are based on cumulative net ET. We are currently programming both these capabilities into the model to enable realistic simulations using historic weather data.

Model simulations for wheat in Australia showed that both yield and water productivity vary greatly with seasonal conditions. Irrigation to avoid water deficit stress greatly increased yield and water productivity, and sprinkler irrigation had higher irrigation water productivity due to slightly higher yield, lower irrigation amount and lower deep drainage losses. Timely sowing also improved both yield and water productivity.

Crop modelling capacity in Nepal has been greatly enhanced as a result of support from The Crawford Fund, enabling two Nepalese visiting scientists to receive on-the-job training with the ACIAR team at CSIRO Griffith in 2004 and 2005. This was followed by a week-long training course for 10 participants at Tribhuvan University, Nepal. As a result, Tribhuvan University has established a multidisciplinary crop modelling group, and two students have commenced Masters degrees in crop modelling.

Sub-project 6. Economic impact assessment of permanent bed systems

The economic analysis of permanent bed systems for rice-wheat, soy-wheat and maize-wheat in Punjab was revisited by the Australian economist (Dr Rajinder Pal Singh) in collaboration with the Indian team. The approach was expanded to include financial analysis, economic analysis (includes corrections for distortions in financial values due to government intervention e.g. power subsidy) and crop sequence analysis for a 20 year duration (includes effects such as decline in yield of transplanted rice on permanent beds during first 4 years, yield increase of wheat in soy-wheat rotation after the third soybean crop). The findings will be reported once the inputs, assumptions and scenarios have been finalised.

A preliminary analysis was done of the impact of switching to permanent raised beds from current layouts used on Australian rice farms. A typical crop rotation was identified for each irrigation layout, and crop sequence gross margins were prepared and compared with the gross margin of a crop rotation on permanent lateral raised beds. There was an increase in the present value of the aggregated crop sequence gross margin in the long term for progressively more developed irrigation layouts. While these preliminary results are very encouraging, they didn't take into account the development costs of the different layouts. The next steps are to undertake a benefit cost analysis of such changes in irrigation layout including development and operating costs, and to identify and compare more rotations with varying lengths for each field irrigation design.

Sub-project 7. Development of stubble management machinery for direct drilled flat and bed farming systems

Dasmesh Mechanical Works and PAU have developed the Turbo Happy Seeder, a very clever approach which eliminates the chute, greatly reduces the amount of dust, and the sowing lines are now much more exposed (with benefits of both better establishment and more accurate sowing). Dasmesh have established trials in ~100 acres of farmers' fields with good results to date (establishment and early growth), watched by over 1,000 visitors. Results with the earlier Combo+ Happy Seeder (with strip tillage and a chute) have also been very good, and procedures are underway for the Happy Seeder package to be recommended by Punjab Agricultural University and included in next winter's package of practices for farmers in Punjab.

The Rice-Wheat Consortium purchased 6 Combo+ Happy Seeders which were sent to 5 locations in India and to the ADB project in Punjab, Pakistan, where it was demonstrated at 7 locations in farmers' fields. Experiments have been initiated to guide development of N management and irrigation strategies for mulched wheat sown with the Happy Seeder. Preliminary results indicate a cumulative saving of 30 mm prior to the first three irrigations due to reduced soil evaporation on a loamy sand in 2004/5, but little saving on a sandy loam where soil water content was very low prior to the first irrigation.

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

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 Fax: 07 3365 2968 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	$998,598
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 120cms, crack during dry seasons and shrink and swell in the regions monsoonal climate. Crop simulations and field experiments have shown soy yields should be around 2.4 t/ha, but most farmers struggle to achieve 1.2t/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 Mt of N, P and K each year, but fertiliser inputs, manure and fixing of nitrogen by legumes replace only 0.7 Mt.

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. 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, with increased levels having 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.

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

Project progress

The latest Annual Report is forthcoming. The previous year's has been included for information.

Year 1 (01/07/2004-30/06/2005)

Farmers in Madhya Pradesh grow a soybean crop during the monsoon season, and then grow a wheat crop during the dry season using moisture stored in the deep vertosol soil, supplemented with some irrigation from groundwater. While the farmers do use fertilizer, this is restricted to modest rates of nitrogen and phosphorus application supplemented with farm yard manure (FYM). Application rates of nitrogen and phosphorus are less than the rate of removal, and there has been little consideration given to other nutrients. The farmers obtain good wheat yields (though lower than the national average), but typical soybean yields are less than expected in this environment.

Nutrient omission trials were conducted for the wheat crop on farmers fields in Geelakhedi (Rajgarh district), Mugaliahat (Bhopal district) and Rangai (Vidisha district) villages. Two replicated experiments were established in each village. In an omission trial, all but one nutrient is applied to the crop. If the omission of a nutrient results in a yield lower than the control plot (where all nutrients are applied), then the nutrient omitted is recognised as deficient in the soil. In addition to dry-matter and grain yield measurements, plant tissues samples and soil samples were also taken for chemical analysis. This approach identified phosphorus, sulfur and zinc as deficient, but showed that adequate levels of iron, manganese, copper, boron and molybdenum were present.

Response to nitrogen application was not tested, as this nutrient is recognised by farmers as being deficient, and is routinely applied as fertilizer. The response to phosphorus on several of the field sites, despite regular applications of phosphatic fertilizer, indicates that the rate of application used has only been sufficient to maintain production, and that no reservoir of phosphorus has accumulated. A reduced program of nutrient omission trials has been established for the 2005-2006 year soybean crop.

A farmer's practice plot was also included to increase the applicability of the trial as an extension tool. The farmers practice plots produced a lower yield than the control in all six trials, effectively demonstrating that the farmer was loosing yield because of poor crop nutrition. The research trials attracted considerable farmer attention, with many farmers making "casual" visits to the site. In addition, several formal village meetings were held to discuss the field trials and the direction of future research. Future interactions with the farming community, and in particular discussion of strategies for overcoming yield limitations, will be fostered by the appointment of two BAIF community workers, and through the appointment of a social scientist at the Indian Institute of Soil Science.

Neal Menzies, Pax Blamey and Ram Dalal visited India in August 2004 (before the project document was signed) to make a preliminary assessment of the soybean crop. This visit was timed to permit the researchers to observe the soybean crop in its late vegetative / early reproductive stage. It was considered that at this time, foliar symptoms of nutrient deficiencies would be most apparent, and that a visit at this time would help the research team to understand the agronomic practices used by Indian farmers for soybean culture. The timing of this visit was an ideal opportunity to assess the impact on the soybean crop of waterlogging; the visit following several weeks of heavy rain. In low-lying areas of the field, where the soil surface was covered with standing water, the soybean crop was stunted and profoundly nitrogen deficient. However, over the majority of the field area, there was no standing water and the crop appeared healthy (plants were green and turgid). Furthermore, while there was some insect damage, and in particular damage from the stem girdling beetle, this was not thought to be sufficient to cause a substantive yield loss.

Several hypotheses to account for the poor soybean yield, despite adequate vegetative growth were developed for testing. The potential limitations to yield considered included, low photosynthetically active radiation levels during the overcast days of the monsoon, and that an early end to the monsoon resulted in water stress during pod-filling. This latter effect could be accentuated by poor exploitation of the soil profile for water, as much of the plants root system in the deeper part of the soil profile may have been damaged by anoxic conditions during waterlogging. The use of a broad bed and furrow (BBF) system would overcome the problems posed by complete inundation of the soil. It may also increase the depth of "healthy" roots during the monsoon, and thus may alleviate some of the problems of rapid onset of drought conditions at the end of the monsoon.

In addition to field experimentation, crop simulation modelling will be used to explore limitations to soybean yield. To provide appropriate crop physiology parameters for this modelling, an assessment of soybean phenology and biomass accumulation was planned, and has been implemented for the 2005-2006 year.

In Australia, no field trials were initiated because of the ongoing drought. In view of this limitation to the progress of the project, the research assistant position at the Department of Natural Resources and Mines was not filled.

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

Overseas Collaborating Countries	India
Commissioned Organisation	University of Western Sydney, Australia
Project Leader	Dr Peter Cornish Phone: 02 4570 1376, mob: 0414 244 269 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 rainfall, from 1,100 to1,600 mm, mainly distributed between June-September with frequent dry spells within the monsoon, little irrigation (so 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 Regional Centre 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; and
- enhance the capacity of PRADAN and NGOs to undertake watershed development work.

Project progress

Year 1 (01/10/2005-30/09/2006)

This project provides a foundation for improved food security and increased cash income for some of the poorest farmers in India, through improved understanding of small watershed hydrology with respect to water harvesting, developing easy-to-use principles for design and implementation of water harvesting technology, evaluation of downstream hydrologic impacts, and developing crop options and farming systems that effectively use land and water resources. The project commenced on 1 April, 2006. Activities within each of 5 project objectives include:

1. Develop, validate and promote water harvesting principles
The basis of Water Shed development (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 in developing 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 have 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 differential 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 level in 7 wells is also being monitored, as well as water level in 4 '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 3 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 (8 from India) at which a participatory evaluation process and framework was developed and a set of indicators.

5. Enhance the capacity of PRADAN (and other NGO's) 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 have been exposed to GIS, which may be introduced into broader activities.

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

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	$1,000,705
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

First progress report due in 2007.

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

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
Collaborating Institutions	
Project Budget	$70,000
Project Duration	01/04/2006 to 30/09/2006
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 optimisng 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 progress

First progress report due in 2007.

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

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
Collaborating Institutions	
Project Budget	$20,000
Project Duration	01/06/2006 to 30/09/2006
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

The development of new farming systems and soil management practices to increase productivity while reducing damage to soil and water resources constitute a real challenge. Conservation agriculture (CA) is a new concept that seeks to increase yields and gain efficiencies in input use while maintaining long tem productivity of land and water resources in turn contributing to increased profitability and sustainability of faring enterprises. The fundamental premise of CA — based in the practice of retaining all residues — is questioned in drier climates where there is more competition for forages and fodder which results in lower levels of residue retention. The aim of this ACIAR project is to assess the potential soil resource and productivity gains achievable by implementing varying levels of crop residue retention in these regions. It will use a modelling approach to determine whether minimum residue thresholds exist that allow farmers to balance their livestock needs with the maintenance of the soil resource.

Project progress

First progress report due in 2007.

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

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 Ray Trewin

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 1 (01/06/2005-31/05/2006)

The project goal is to provide policy makers 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. Project objectives are: 1) to develop 4-5 alternative development paths or scenarios for agriculture and related KST policies out to 2050; 2) to develop quantitative scenario results using the models proposed for this project; 3) to analyse the results of both quantitative and qualitative scenario outcomes and to develop implications for investment based on these outcomes; 4) to analyse the economy-wide implications of trade and subsidy policies within these scenarios; and 5) to disseminate research results.

The project is being implemented in close collaboration with the 2-year IAASTD initiative (www.agassessment.org). Objectives 1-3 are implemented closely with IAASTD, whereas 4 and 5 are carried out independently with ACIAR project partners in China, India, and Australia. Moreover, the project focuses more on the quantification of scenarios than development of storylines. Outputs under Obj. 1 & 2 were scheduled to be achieved during the first reporting period; moreover, Obj. 5 is ongoing throughout the project period.

Activities under Obj. 1 relate to a) development of storylines, b) development of alternative KST policies; and c) testing of scenario plausibility and quantification.
Specific Outputs include:

1.1 Drivers for agriculture and AKST policies identified; scenarios developed.
1.2 KST policies developed for each of the alternative scenarios.
1.3 4-5 plausible, internally consistent, challenging, novel, substantial and relevant agriculture scenarios in the form of narratives describing distinctly different pathways from the 2005 to 2050 for agriculture productivity growth, food security, livelihoods and environmental sustainability and the role of science and technology in shaping the pathway

These outputs have been achieved. However, the 4 scenarios developed to date are yet to go through two rounds of review, after which they will be further refined and updated. Instead of a separate 5th scenario, changes for 2 of the other scenarios will be developed so as to allow these scenarios to get closer to the targets of the MDGs. Macro-economic drivers are based on those used in the Millennium Ecosystem Assessment (MA). Other outputs include development of conceptual frameworks for scenario analysis; finalization of chapter outlines; and decisions on drivers.

Obj. 2 focuses on a) quantification of drivers and development of productivity and growth trends; b) adaptation of models; c) implementation of model simulations; d) readjustment of model parameters based on feedbacks; and e) readjustment of descriptive scenarios based on modelling results.
Specific Outputs include:

2.1 Quantitative relationships for alternative scenarios for the models
2.2 Models adequately address quantifiable scenario components
2.3 Model results quantifying paths of agricultural production, consumption and trade by scenario
2.4 Improved scenario results in iteration with scenario narratives
2.5 Improved scenario narratives in iteration with model simulations

During the first reporting period, Outputs 2.1-2.3 have been achieved. Feedback loops/iterations among models have not yet been implemented, however. They will be realized in the first half of the second reporting period.

The research activity under Obj. 5 that relates to the first year of implementation is to hold coordination meetings and consult with collaborators. Given the complexity of this research project, a lot of emphasis has been accorded to meetings—significantly more than originally envisioned—4 meetings.

In particular, project researchers attended the following meetings:
1) Jan 30–Feb 3, 2005, Bangkok: Global Scenarios Meeting—to develop the conceptual framework for scenarios work and a draft outline
2) April 9-12, 2005, Beijing: ESAP Design Meeting—to develop the outline and conceptual frameworks for the Asia region
3) May 23-25, 2005, Montpellier: Integrated Design Team meeting—to finalize conceptual frameworks & outlines.
4) July 18-20, 2005, Rome: IAASTD meeting on global and regional scenarios—to discuss and agree on drivers and start the development of qualitative storylines
5) October 11-15, 2005, Washington: 1st Global Scenario Working Group Meeting—to integrate regional and global scenarios, further develop storyline drivers, and AKST policies
6) January 22-25, 2006, Rome: IAASTD Scenarios Storyline Meeting—to finalize the draft of 4 storylines
7) April 3-5, 2006, Washington: ACIAR-IFPRI Workshop on Exploring Alternative Futures for Agricultural Knowledge, Science and Technology—to finalize drivers to be quantified, model parameters, and model interactions.
8) May 2-5, 2006, Bangkok: 2nd Global Authors Workshop—for Scenarios to interact with historical trends and implications of scenario outcomes; and to discuss storyline and quantifications, and a first set of model results.

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

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 Bill Winter

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 is sown to pearl millet with more than two thirds of seed being 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 very 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 seeds to the private sector, so is ideally placed to ensure the delivery of improved varieties to smallholders through the existing hybrid production system.

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

The latest Annual Report is forthcoming. The previous year's has been included for information.

Year 1 (01/07/2004-30/06/2005)

India project summary
The project addresses improvement of animal productivity in crop-livestock systems in the driest rainfed parts of India where pearl millet (*Pennisetum glaucum*) is the only reliably productive cereal. Pearl millet stover is a major component of ruminant diets in these production systems. The project aims to use both marker-assisted and conventional plant breeding to genetically increase the nutritive value of pearl millet stover. In the present project reporting period the following three objectives were addressed a) produce hybrid parent lines with enhanced stover quality suitable for use in commercial hybrid seed production, b) determine the effects of individual genomic regions (so called "quantitative trait loci" or QTLs) controlling stover quality, and combinations of these in enhanced commercial hybrid parents, on *in vitro* stover quality and *in vivo* animal production, and c) promote the use of improved parental lines to public and private seed companies.

The project commenced in June 2004 and in August 2004 stakeholders from various national and international public and private organizations were convened for the project planning meeting to discuss the objectives and activities of the project. There was strong support for the project and a consensus that the project has the potential to improve smallholder livestock production in India.

The 1st project year saw successful linking of laboratory quality traits for pearl millet stover with livestock productivity measurements. The *in vitro* true digestibility of stover determined after 48 hrs of incubation in rumen inoculum was found to be the single most important laboratory trait related to *in vivo* measurements in sheep that identify with animal performance, such as organic matter digestibility, organic matter intake, digestible organic matter intake and nitrogen balance. Other laboratory traits related to livestock-pertinent measurements were stover protein content, cell wall (NDF) content, cell wall digestibility and metabolizable energy content. Near Infrared Spectroscopy (NIRS) was successfully calibrated for these stover laboratory traits using pearl millet mapping population for ICMB 841 863B.

An improved pearl millet linkage map was constructed based on the ICMB 841 x 863B mapping population using newly developed SSR, EST-SSR and TRAP markers, which facilitated subsequent mapping of reliable QTLs for use in marker-assisted breeding. Major QTLs for several stover quality traits were identified on different pearl millet linkage groups from two different tester backgrounds and three different plant stover fractions. Consistent QTLs from this analysis will be used for marker-assisted backcross breeding. SSR, EST-SSR, and TRAP markers were screened against four recurrent parents and four donor parents to identify genomic regions for which marker polymorphism is sufficient for marker-assisted selection using QTL-flanking marker loci.

Marker combinations for the different trait donor line x elite line cross combinations were selected for use in the marker-assisted backcross breeding program. New polymorphic markers were identified from this experiment and these will be included in the existing pearl millet linkage map. BC1F1 seeds were generated for different parent by parent combinations and a few hybrids were chosen for generation advancement. In addition, several late-generation breeding lines having introgressed stover quality QTLs from donor 863B in the genetic background of elite hybrid parental line ICMB 841 were identified.

In 15 commercial hybrids, stover protein content ranged from 6.1 to 8.1% (LSD = 0.12%), stover *in vitro* digestibility from 43 to 47% (LSD = 2.4%), and stover metabolizable energy content from 6.0 to 6.7 mega joule per kg (LSD = 0.4%). Digestible stover yield (stover yield times stover *in vitro* digestibility) per ha ranged from 1.0 to 1.8 tons. Digestible stover yield and grain yield were positively associated ($r = 0.54$; $P = 0.04$) suggesting that substantial cultivar-dependent variation in stover quality exists that can be exploited without detriment to grain yield.

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

Overseas Collaborating Countries	India
Commissioned Organisation	International Water Management Institute, India
Project Leader	Dr Anju Gaur Phone: +91 40 30713071 Fax: +91 40 30713074/75 Email: a.gaur@cgiar.org
Collaborating Institutions	University of Melbourne, Department of Civil and Environmental Engineering, Australia Jawaharlal Nehru Technological University, Centre for Water Resources, India
Project Budget	$1,120,244
Project Duration	01/07/2004 to 30/06/2008
ACIAR Research Program Manager	Dr Christian Roth

Project background and objectives

India's Krishna River Basin covers an area in excess of 250,000km², 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 focussed 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 that 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. Providing the relevant information to ensure decision making results in sustainability and caters to the needs of a growing population while not exceeding levels of likely supply is the Tribunal's challenge. Helping provide that information is the focus of the project.

By providing technical and economic information and decision support to the Central Water Commission and Ministry of Water Resources, as advisory agents to the Krishna Basin Tribunal, and to the riparian states water productivity in agriculture in the Krishna Basin will be improved.

Project progress

Year 2 (01/07/2005-30/06/2006)

Research activities were focused on three sub-basins: Musi, Malaprabha, and Upper Bhima from the three riparian states, Andhra Pradesh, Karnataka and Maharashtra, respectively. The Musi represents a wide spectrum of water use and demand patterns: urban demand in the Hyderabad mega-city area, medium-sized irrigation projects in mid-basin, and the lower catchment dominated by Nagarjuna Sagar, a major irrigation project, and increasing industrial demand in various places. The Malaprabha sub-basin is located in a semi-arid area. The Malaprabha major irrigation project and several groundwater and lift irrigation schemes are located in the sub-basin. The upper Bhima has Pune as the major city in Maharashtra and has water use and water quality components similar to those of the Musi. There is also hydropower generation in the Bhima sub-basin.

The tasks set out in the work plan for the year were largely accomplished. For the WEAP model the basic input file configuration was completed and Krishna basin data loaded. In addition, WEAP and REALM nodes for the basin were identified and data loading is in progress. A preliminary REALM model for the Musi sub-basin is ready with six supply and seven demand nodes (the data gaps to be filled). A concept paper on "water allocation modelling" was presented in an IWMI-TATA conference. The paper outlines the proposed methodology not only for assessing the social costs and benefits of competing demands for water but also for encompassing a number of issues such as urbanization, extensive spatial and temporal variability, public investment in infrastructure and changing water-quality parameters.

In the course of the year, several research papers, journals articles and conference papers were published. A research report on water balance and changes in the hydrology of the Krishna basin demonstrates that the largest water transfers takes place from the Upper to the Lower Krishna river. The same study report shows that the development of irrigation projects and rainwater harvesting schemes have dramatically decreased outflow to the ocean from 28 percent of rainfall in the first 60 years of the twentieth century to almost 5 percent over the remaining 40 years and thereby effectively "closing" the basin. Another article presents the mapping of diverse irrigated areas in the Krishna river basin using an irrigated fraction approach and MODIS images (year 2000). The mapping indicated that out of the total basin area, 24 percent was irrigated in 2000.

The other articles focus on assessment of water resources and water balance modelling in the Musi sub-basin. This sub-basin has a very large area irrigated by different sources such as canals, tanks, groundwater and wastewater. The upper part of this sub-basin is dry compared to the lower part and the runoff to rainfall coefficient varies from 0.07 to 0.24. Altogether, 854 million m3 (MCM) of water are available in the Musi sub-basin, with 170 MCM and 110 MCM imported from Godavari and Nagarjuna Sagar, respectively, for the Hyderabad city. A water balance model was developed for the Hyderabad city to study the changes in the local water cycle and evaluate the potential water sources within the city. The net groundwater recharge from the city was estimated as 39 MCM which is much less than the groundwater extraction for urban use (60 MCM). The total outflow from Hyderabad city in the form of runoff and sewerage is 298 MCM, where the runoff is the major component with 56 percent contribution, which is the result of the urbanization. It is anticipated that 30 percent of the total water will be met by the Krishna river, which will place some stress on agricultural water supply in the Nagarjuna Sagar reservoir during dry years. The spatial variation in land use of the Nagarjuna Sagar command was assessed for a dry year and it was found that head-enders suffered most due to lack of information on reservoir operation and no alternative source of irrigation.

The economics component of the project is well under way. The initial focus is on the Musi sub-basin. The economic model has been constructed with the objective of linking it to the hydrological model. Thus, the economic implications of changes in the allocation of water to different nodes can be assessed on a monthly basis. The economic model is deterministic, but one that is capable of being changed into a stochastic one, if required. The methodology used in the Musi will be applied to the other sub-basins selected for study.

A study in the Lower Krishna river basin looks at the evolution of formal and informal institutional arrangements and agrarian changes over time in response to growing water scarcity. This study will come up with an effective governance system that would allow water allocations, which satisfy human needs and environment requirements and potentially minimize water-related conflicts in the basin.

A meeting of the Project Advisory Panel was held on November 15, 2005. Representatives from the three riparian states attended the meeting. The panel supported the overall direction of the project, in particular, the two-tier approach to study water allocation at the basin and sub-basin levels. The panel recommended that groundwater assessments should be included in the project.

Pakistan

Bilateral

HORT/1995/003: Control of gemini virus diseases of cotton and tomato in Pakistan and Australia

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	CSIRO Plant Industry, Australia
Project Leader	Dr Ali Rezaian Phone: 61 8 8303 8634 Fax: 61 8 83038601 Email: ali.rezaian@csiro.au
Collaborating Institutions	The World Vegetable Center, Taiwan National Institute for Biotechnology and Genetic Engineering, Pakistan
Project Budget	$907,750
Project Duration	01/01/2001 to 30/06/2006 (Project extended from 01/01/2005 to 30/06/2006)
ACIAR Research Program Manager	Mr Les Baxter

Project background and objectives

Over the past decade geminiviruses have emerged as devastating disease agents infecting major crops in many regions of the world. The epidemics are linked to the spread of a new form of the whitefly, *Bemisia tabaci*, a particularly efficient vector of geminiviruses. The resulting diseases of concern in this project are cotton and tomato leaf curl. The recent rate of spread and the scale of damage caused by geminiviruses worldwide now rank them among the most serious plant diseases on record. Geminivirus epidemics in Pakistan during the 1990s have been severe, and combined losses to cotton and related industries have been estimated to exceed Pak Rs 162 billion (over A$5 billion).

In Australia tomato geminivirus has been recorded in the Northern Territory for many years, however it has not previously been a serious problem because the indigenous form of *Bemisia tabaci* is a relatively poor vector (virus carrier). The new more efficient biotype (B) of the virus, which is spreading through northern and eastern Queensland and NSW, is predicted to meet the geminivirus very soon. The resulting crop losses are forecast to be well in excess of $100 million annually. The damage caused by geminiviruses in Pakistan is having an impact of national magnitude on the country's economy. Scientists in Pakistan have attempted disease control through the use of pesticides and change of agronomic practices, but no significant control has been achieved.

This project is undertaking research leading towards production of disease-resistant lines, which are urgently required in Pakistan as well as many other developing countries. The focus is on developing transgenic resistance as it offers a higher likelihood of success than conventional means that have so far proven ineffective. The project will also evaluate tomato genotypes produced in an existing breeding program for natural geminivirus resistance.

Project progress

The latest Annual Report is forthcoming. The previous year's has been included for information.

Year 4 (01/01/2004-31/12/2004)

Field surveys of geminiviruses:

Cotton leaf curl disease (CLCuD) is a major constraint to the production of cotton in Pakistan. The disease is caused by a combination of a DNA â and either Cotton leaf curl Alabad virus, Cotton leaf curl Multan virus (CLCuMV), Cotton leaf curl Khokhran virus (CLCuKV) or Papaya leaf curl virus. The DNA â is responsible for disease symptoms and depends on CLCuV for replication and encapsidation.

Field surveys indicated the resistance breaking variants of CLCuV were spreading in the Punjab. A recombinant DNA A with sequences derived from CLCuMV and CLCuKV was found to be associated with resistance breakdown. A diverse number of DNA was also isolated and sequenced.

A severe epidemic of tomato leaf curl disease has appeared in tomato crops in the Sindh province. Both ToLCNDV and Tomato leaf curl Bangalore virus and a DNA were found in diseased samples. Surveys of other crops revealed ToLCNDV, Zucchini yellow mosaic virus and ChLCMV with recombinant DNA s in chilies, melon, Ageratum conyzoides and papaya.

Viral genome characterization:

We have already showed that a complementary-sense ORF of CLCuV DNA â, âC1, is required for inducing disease symptoms. The expression of the âC1 ORF from a Potato virus X (PVX) vector developed symptoms of CLCuD in tobacco confirming that the âC1 is involved in pathogenicity. The function of âC1 protein in virus movement was investigated. Tomato plants co-inoculated with a movement deficient component A of TLCNDV and CLCuV DNA â exhibited severe symptoms and contained replicative forms of both DNA A and DNA â in the newly developing leaves. The control tomato plants inoculated with DNA A alone did not show any symptoms and Southern blot analysis failed to detect the virus. Transient expression of DNA â/GFP fusion protein in onion and Nicotiana benthamiana indicating that the âC1 localized to the cell periphery in epidermal cells of these plants. Together, these results indicate that âC1 plays a role in systemic spread of the virus. The ability of DNA â to be supported for replication by a number of geminiviruses combined with its ability to spread a movement deficient virus component is probably contributing to the emergence of new diseases in tropical and sub-tropical crops.

The role of nuclear shuttle protein (NSP) and movement protein (MP) genes in pathogenecity of ToLCNDV was investigated. No phenotypic changes were observed when MP was expressed through a PVX vector and under the Cauliflower mosaic virus (CaMV) 35S promoter. The expression of NSP from PVX developed downward leaf curling in N. benthamiana and hypersensitive response (HR) in N. tabacum and tomato. This suggests NSP of ToLCNDV is a pathogenicity determinant. Mutagenesis analysis showed that the N-terminal amino acids of NSP are important for the hypersensitive response in tobacco. To study the role of NSP in the suppression of gene silencing, several gene constructs in fusion with GFP have been produced.

Development of virus-resistant plants through genetic engineering:

Transgenic tobacco plants transformed with an RNAi construct of CLCUV targeting either complementary-sense genes (AC1-AC4) or both DNA A and DNA â were resistant to infection by the homologous virus. Transgenic plants were also exposed to field isolates of CLCuD by whitefly inoculation. Two out of ten lines developed disease symptoms. The geminivirus in these infected plants was identified as ChLCMV and DNA â of CLCuV or chili beta. These results indicate that induced resistance may be virus-specific.

A cotton genotype (NIBGE-115), that was found to be completely virus free when inoculated with the resistance breaking strain, was multiplied and is being used as a source of resistance in the breeding program at NIBGE. Cotton lines transformed with silencing constructs targeting DNA A sequences (AC1-AC4) have shown promising results in field trials at Vehari station where breakdown of natural resistance is a major problem. An RNAi construct targeting AC1 and âC1 simultaneously has been transformed in cotton and fifteen plants were regenerated from various batches of hypocotyls inoculation experiments. These lines will be tested for virus resistance at the F1 stage.

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

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, mobile: 0419 317 454 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 trail 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 2 (01/01/2005-31/12/2005)

The first objective of the project and a focus of project activity during the period has been to progress the establishment of two Serial Biological Concentration (SBC) demonstration sites in Punjab and Sindh provinces. Following a site assessment trip in Dec 2004, suitable sites were identified on a privately owned and operated farm at Bhalwal in Punjab and on the PARC research farm near Thatta in Sindh.

The site designs were finalised during January and February. At Bhalwal a 1 ha, tile-drained Stage A was designed to be irrigated from an existing shallow tubewell (1.5 dS/m). Stage B, 0.35 ha, was designed to be irrigated with the tile drain effluent from Stage A, and Stage C (0.1 ha) to be irrigated with the tile drain effluent from Stage B. The tile drain effluent from Stage C was designed to be pumped to a small pond. At Thatta, Stage A was designed to be 1.4 ha and irrigated by surface water of 0.8 dS/m. Stage B was designed to be 0.5 ha and irrigated using the tile drain effluent from Stage A, with the 0.2 ha Stage C irrigated by effluent from Stage B tile drains. The effluent from Stage C tiles was designed to be pumped to a small pond.

Construction of both sites occurred in the period March to June. Significant problems were experienced during construction due to flooding of excavated trenches by groundwater and slumping of trench walls.

Representatives of the Australian team visited both sites in June after construction at Bhalwal was completed and during construction at Thatta. The selection of an initial maize crop was made at both sites, and the establishment of monitoring protocols was discussed at each site. The Pakistan team did an outstanding job to complete construction of both sites in time for late sowing of an initial Kharif maize crop in August. Unfortunately, torrential rains at both sites and flooding at the Thatta site ruined the initial crop. Both sites were subsequently prepared for a winter wheat crop which was sown in November. Australian team member, Shahbaz Khan, visited both sites during December. A brochure explaining the project was prepared for use in Pakistan.

The second objective is to analyse the financial viability of SBC systems in Punjab, Sindh and the Murray Darling Basin. Acquisition of relevant Pakistan SBC data has commenced and information on agricultural productivity with respect salinity and waterlogging in both Pakistan and the Murray Darling Basin continues to be compiled. A financial model for SBC developed for the Murrumbidgee region has been assessed to be a very suitable tool that can be adapted for wider application in the Murray Darling Basin and Pakistan.

The third project objective is to assess the scope for adoption of SBC technology in the irrigation areas of the Murray Darling Basin. A Geographical Information System has been used to develop a regional SBC suitability analysis, using estimates of thresholds for SBC suitability criteria in the Murrumbidgee Irrigation Area (MIA), Shepparton Irrigation Region (SIR) and the Murray Irrigation Limited (MIL) area of the MDB. The aim of the analysis was to provide a ranking of the relative suitability of land for SBC application within these regions, based on biophysical factors. Suitability thresholds were defined separately for each of the physical factors (groundwater depth and salinity, soil hydraulic conductivity and salinity), and then combined to derive suitability classes which reflect the relative probability of finding suitable land for SBC.

Objective 4 is to develop an analytical framework to assist in the selection of the best management system for a range of saline drainage effluents. Work on developing a framework for comparing different options for managing subsurface drainage water is progressing. The options for managing sub-surface drainage and implications for salt mobilisation have been conceptually grouped into four categories:

i) Reduce sub-surface drainage.
ii) Regional redistribution.
iii) Local storage.
iv) Export of salt to river.

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

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 2 (01/01/2005-31/12/2005)

Sub-objective 1. In the Mardan district of Pakistan identify the soil management practices for permanent raised beds that maximise their productivity and minimise groundwater accession.

The Rabi wheat (2004-05) and the Kharif maize (2005) crops were the first grown using the Australian-made PRB machinery. The 2004-05 wheat crop was affected by rust and unseasonal waterlogging. Yields were still 'good' and showed a 17% increase in favour of the wide PRBs and 3% for the narrow beds, respectively, the district average for basin irrigated wheat (=control) being 2.9 t/ha. The waterlogging was caused by runoff water from large rains being unable to drain from the fields.

The 2005 maize crop was a hybrid variety sourced from the USA by Cluster Group Leader Nobat Kahn. This variety has the potential to raise yields from ~4.5t/ha to 8.0 to 9.0 t/ha and has generated a lot of framer interest. Yields on wide beds were 18% above the control (7.1 t/ha), those on narrow beds 4% higher. Irrigation water savings on PRBs were consistent with past trends, showing savings of 28% and 33% for wheat and maize over the control, respectively. In addition, the 'Depletion Replacement' irrigation treatment is indicating additional water savings of 5% to 7% are achievable for crops on PRBs beyond the above water savings when comparing 'Depletion Replacement' irrigation with district practice on PRBs, and further savings are expected as expertise with PRB farming increases.

Research methods to quantify changes in soil conditions, refine irrigation practices and analyse the profitability of PRB farming have been instituted.

Sub-objective 2. Stimulate the adoption of permanent raised bed farming in the Mardan District of Pakistan

Use of PRB bed forming/renovation and no-till seeders
Additional training and supervision was given to achieve near-optimal PRB dimensions and soil conditions. These sought to: (i) standardise 3-point linkages and settings, (ii) increase the length of the gauge wheel shafts on the bed-former; (iii) operate the machines in drier soil, and (iv) apply less pre-seeding irrigation. Such assistance is likely to be needed for 6-8 cropping seasons after the machinery is handed over.

Machinery repayment
The Bank Account for both Cluster Groups to deposit their repayments for the cost of PRB machinery was opened in May, 2005 at Mardan. Repayments from participating farmers are being lodged after harvest, and the scheme is operating as planned. Additional Group income is being obtained from the hire of PRB machinery during the growing season, plus savings from: (i) reduced pre-seeding cultivation and watering, (ii) approximately 50% less seed and fertiliser being needed (PRBs occupy 70% of any given field); and (iii) the virtual removal of the need to thin maize seedlings.

Cluster Group Crop Results
The hybrid maize grown in 2005 was hitherto regarded as too costly. It has nearly doubled maize yields, and farmers are now changing from tobacco to maize on PRBs as a result. Group yields continue to replicate those of the research team and are significantly higher than the average district practices (basin irrigated; traditional, non hybrid maize). The Kahn Cluster Group lined its supply canal and installed tail-water drainage. The lining has sped the arrival of water from the supply line to fields from 6 hours to 6 minutes. The tail water drainage protects against flooding and waterlogging caused by excess rain.

Extension and demonstrations
A Field Day in March 2005 attracted about 40-50 farmers. The results of research into PRB farming, plus the experiences of Cluster Group farmers, were explained. Visitors were able to compare crops grown on PRBs with those grown in normal basins. The research team installed about 10 PRB demonstrations on the land of farmers not in Cluster Groups. Some were as large as 3-5ha in a single basin. The demonstrations are part of a strategy to facilitate the formation of two new Cluster Groups and create a demand for the locally manufactured machinery.

Local manufacture of PRB machinery
A local manufacturer was selected and given a contract to produce two bedformer/renovators and two no-till seeders. These will be paid for by funds accumulated from the repayments made by the first two Cluster Groups. Delivery is scheduled for February-March 2006.

Sub-objective 3. Assess the potential for permanent raised beds to reclaim waterlogged and saline cropland in Western Australia

Monitoring root-zone salinity in a range of seedbeds has shown PRBs leach more salt early in the growing season and suffer the least accumulation at the surface over summer. However, the PRBs, accumulate more salt at the base of their seedbed (20-30cm).

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

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	CSIRO Land and Water, Australia
Project Leader	Dr Elizabeth Humphreys Phone: 0400 601 528 Email: Liz.Humphreys@hotmail.com
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 Mha of rice-wheat (RW) systems of Pakistan, and in the 0.15 Mha 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. In 2002 the Happy Seeder was conceived, designed, built and tested by John Blackwell (CSIRO Land and Water) at Punjab Agricultural University, India through ACIAR project SMCN/2000/89. The first Happy Seeder consisted of a seed drill attached to the rear of a forage harvester, which cuts the stubble and deposits it behind the seed drill. In 2003 Shabbir Khan and team (Pakistan Agricultural Research Council) designed and built the FMI seeder which combines the flail chopping, sowing and mulching operations into a single compact machine. In 2004, a 4 m wide version of the Happy Seeder suited to broadacre conditions in Australia was designed and built by John Blackwell, with funding from Twynam Pastoral Co. Pty Ltd.

While the problem of sowing into heavy residues has almost been solved mechanically, our 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 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 improvement in Mark III are reduced weight (~550 kg) and improved operator visibility and straw spreading.

2. Installation of 3 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 Prime Minister, the DGs of PARC, NARC and Punjab OFWM) have already been familiarised with the technology and most have visited some of the field sites.

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

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
Collaborating Institutions	
Project Budget	$70,000
Project Duration	01/04/2006 to 30/09/2006
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 progress

First progress report due in 2007.

Bangladesh

Bilateral

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

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: ksiddiqu@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 , Bangladesh
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 largest planted crop in Bangladesh after rice. This reflects the importance of pulses as a source of protein in Bangladeshi diets. The dominant pulse crops grown are lathyrus, lentil, chickpea, black gram and mung bean with the Gangetic Plain in the country's west the main area of pulse cropping. Of these chickpea is an important part of diets, providing a high level source of protein (21.7 per cent)along with complex carbohydrates, dietary fibre, unsaturated fats and essential vitamins and minerals. Low productivity characterises pulse production in Bangladesh. Cereal production has higher yields than pulses. The potential yield expected for pulse crops grown in similar conditions is not matched. Chickpea particularly has failed to reach its potential. Demand for chickpea has remained at a constant high with much of this met by importing rather than domestic growth. Between 1995 and 1999 imports of chickpea rose by more than 50,000 tons (source: FAO).

The decline of chickpea production that has fuelled rising imports is due largely to a single factor — the foliar disease Botrytis Grey Mould (BGM). Epidemics of BGM have reduced yields and with them seed supplies. The lack of control against it has eroded farmers' confidence in planting chickpea. In Australia similar outbreaks of BGM have the potential to become epidemics. Known controls — 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. An integrated disease management (IDM) approach offers the best strategy for control in both countries.

The project is addressing this to better manage outbreaks of BGM in order to increase yield of chickpea and stability of yield over seasons, by optimising the cultivation of chickpea in traditional chickpea-growing areas of Bangladesh, and improving production both in Australia and Bangladesh through the implementation of integrated disease management strategies.

Project progress

Year 4 (01/07/2005-30/06/2006)

The project has continued to make good progress towards all planned objectives. Project reviews and site visits were undertaken in Australia in September 2004 and in Bangladesh in March 2005. Dr Abu Bakr, the project leader in Bangladesh, participated in the project review in Australia as did the majority of project staff from the various Australian partner organisations. The review in Bangladesh was attended by Mr Bill MacLeod, the Project Officer from CLIMA, Mr Daniel Isenegger from the University of Melbourne and Dr Krishna Kishore Gali from ICRISAT in India.

During the current year, further field screening of entries from Australia, India and Bangladesh was carried out at Ishurdi and Jessore in Bangladesh in the 2004-05 growing season. A total of 220 entries were screened, many being entries that showed better than average resistance in the 2003-04 nurseries in Bangladesh. Of significance in this year's field screening is that 20 lines being retested from the 2003-04 nursery were again shown to be moderately resistant. Screening of chickpea lines for BGM resistance has been undertaken in controlled environments at ICRISAT, in India, and Horsham, Victoria. The BGM and Ascochyta blight resistance status of 117 lines, previously tested in 2003-04, was confirmed in testing at ICRISAT. Of 117 lines tested, 108 lines were found to be moderately resistant to BGM. At Horsham, 139 entries were screened, only 3 were assessed as being moderately resistant and the majority were moderately susceptible.

The genetic variation of 173 isolates collected in Bangladesh in March 2003 and 2004, plus additional isolates from India and Nepal, has been analysed. For the Bangladesh population a high level of genetic variation was found with significant sub-population differentiation and evidence of gene flow. This indicates that the Botrytis cinerea population causing BGM of chickpea has a high adaptive potential and this will need to be considered in breeding for BGM resistance. The durability of resistance will depend on the number of genes and mechanisms controlling resistance. On-farm chickpea variety trials were conducted in Bangladesh using participatory varietal selection techniques to determine farmer preferences in BGM-prone region. Yield and farmer preference were highest for the two currently recommended varieties, BARI Chola 5 and ICCL 87322. Seed increase was undertaken by three villages; farmers were provided seed of BARI Chola 5 to grow on about 7 ha at each village. At harvest, farmers were trained in appropriate seed preservation techniques.

On-farm evaluations of the integrated crop management package for chickpea were moved from the five districts where successful evaluations were conducted in the previous two seasons. One hundred demonstrations of the optimum integrated crop management (ICM) package were planned for each of these five districts. The demonstrations were in clusters of 5 around a village, with 20 clusters achieved in each of four districts and only 18 in the fifth, Faridpur. A comparison with the yield of farmer practice (FP) was established by measuring yields in four nearby farmers' fields. In each district mean yields exceeded 1 t ha-1, making chickpea competitive with other Rabi (winter) field crops. Yield increase of ICM over farmer practice was similar to that obtained in evaluations in this, and previous, seasons. The major constraints for chickpea production in this season were collar rot, pod borer damage and rainfall near harvest. Further improvements in the stability of chickpea yield will depend on management of collar rot and pod borer

On-farm evaluations were conducted in three new districts, Kushtia, Chuadanga and Pabna. Twenty evaluations were established in each district following the protocol established in previous years. ICM gave a significant yield improvement over FP; these increases were similar to those achieved in evaluations during the previous two seasons

In Bangladesh, a training workshop was attended by 48 research and extension staff based in the five Districts under this Project. Presentations were made on the integrated management studies. The workshop formulated a program for the 2004-05 growing season. Pre-sowing training was organized for farmers participating in the on-farm demonstrations and evaluations. Altogether 490 farmers attended this training program. During the growing season training in BGM and pod borer management was given to 38 farmers participating in OFEs. At the seed village, farmers and Block Supervisors, were given training in post-harvest processing and preservation of chickpea seed. In Australia, training in extension methodology was provided to the first Trainee from BARI.

Annual reports from project partners, reports on specific activities and publications arising from project activities are attached as Appendices to the report.

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

Overseas Collaborating Countries	Bangladesh
Commissioned Organisation	International Center for Agricultural Research in the Dry Areas, Syria
Project Leader	Dr Bassam Bayaa Phone: 963 21 2213433, 2213477, 2225112, 2225012 Fax: 963 21 2213490 Email: b.bayaa@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 31/12/2007 (Project extended from 01/07/2007 to 31/12/2007)
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 *A. fabae* were collected in Syria, single-spored, characterized morphologically, and are currently being analyzed 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.

Other South Asia

Bilateral

HORT/2004/010: Building integrated pest management capacity in Iraq initially concentrating on control of jasmine whitefly in the citrus/date system of central Iraq

Overseas Collaborating Countries	Iraq
Commissioned Organisation	CSIRO Entomology, Australia
Project Leader	Dr Paul De Barro Phone: 07 3214 2811 Fax: 07 3214 2885 Email: Paul.DeBarro@csiro.au
Collaborating Institutions	Ministry of Agriculture, Iraq
Project Budget	$488,129
Project Duration	01/01/2005 to 12/05/2007 (Project extended from 01/07/2006 to 12/05/2007)
ACIAR Research Program Manager	Mr Les Baxter

Project background and objectives

Citrus and dates are intercropped, primarily in the central Governates of Iraq. Approximately 2.2 million people in these areas derive some income from citrus and or date cropping. In this system citrus trees are grown as an under-story to date palm plantations, making the management of one very likely to impact on the other. Pests are a major problem of both crops with insecticide spraying being the main management method. Jasmine whitefly is the number one pest of citrus, but unlike most other crop and horticulture pests, lacks an effective control regime. The citrus system experiences losses of up to 100kg per tree, reducing yields to around 30 per cent of what should be possible. In part this is because of impacts on citrus from the control regime for the leading pest of dates, dobas bug, which reduces date yields by up to a third. The lack of effective control for jasmine whitefly has seen the issue prioritised as one of high importance by the Iraq Ministry of Agriculture.

Dobas bugs are controlled through aerial pesticide spraying. This presents several problems, not least to farmers living nearby. The spraying also kills natural enemies of jasmine whitefly, but does not kill jasmine whitefly. Dobas bugs also pollute the canopy of citrus trees leading to a mould developing that further reduces growth and yield. The total estimated losses to both citrus and date cropping is around A$100m a year. Integrated pest management, utilising the latest research and aimed at controlling both whitefly and dobas should substantially boost production.

A strategic framework and complementary implementation skills for the control of insect pests within the citrus/date production system are being developed as part of a National Strategy Plan for the management of jasmine whitefly in citrus.

Project progress

Year 1 (01/01/2005-31/12/2005)

The first stage of the project involved holding a workshop to develop the National Strategic Plan for the management of jasmine whitefly in citrus in citrus/date systems in Iraq. The workshop was held at CSIRO Entomology, Long Pocket Laboratories in Brisbane from 22-25 Aug 2005.

Participants at the workshop comprised senior scientists from Iraq (6) and Australia (9), with a range of expertise relevant to IPM and biological control of insect pests. The objectives of the workshop were to:

- Develop a strategic framework for pest management in Iraq.
- Develop a National Strategic Plan for the management of jasmine whitefly in citrus in citrus/date systems in Iraq.
- Develop a plan for the implementation of the National Strategy, including identification of 5 trainees for hands-on experience as part of CP/2004/010.
- Prepare a proposal and recommendations for consideration by the Iraqi Jasmine Whitefly Committee.
- In addition, the participants' expectations led to the identification of further objectives, which were to:
- Focus on applied and practical aspects rather than theoretical.
- Assess the possibility of using Australian parasites and predators.
- Develop professional relationships to mutual benefit through the free exchange of ideas and sharing of knowledge and expertise.

Project outputs and outcomes

The outputs of the workshop, the development of the Strategic Plan and a decision on the selection process for the young Iraqi scientists who will undertake the 6 month training in IPM in Australia were both achieved and are detailed in the document *The management of Jasmine Whitefly and Dubas Bug in the date palm citrus complex of central Iraq: National Strategic Plan*. The outcome and achievement of the broader objectives in terms of the implementation of successful IPM in the citrus/date system will depend on how the well the plan is adopted by the Iraqi government. This will require considerable future discussion, planning and development.

Workshop structure

The workshop was structured to achieve the objectives as follows:
Welcome, briefing, including,

- Participant expectations of pest management in Iraq to be noted for.
- Participant expectations of the workshop.
- Getting Australian participants to understand Iraqi agricultural systems,
- Presentations by Iraqi participants on Iraqi agricultural system, the citrus/ date production system, and the current citrus/date pest management system in Iraq.
- Feedback from Australian participants to verify their understanding.
- Outlining the issues/questions that need to be addressed in developing a National Jasmine Whitefly plan,
- Conducting SWOT analysis.

Identification of the major issues/questions that need to be addressed in the National Strategy.

- Agreement on the major issues/components of the national plan for Iraq.
- Developing the Jasmine whitefly plan, with the following components,
- **Vision** – what we want Iraqi pest management to be noted for.
- **Mission** – the prime purpose of the national jasmine whitefly committee.
- **Outcomes** – what we want the jasmine whitefly committee to achieve.
- **Critical Success Factors** – what we need to be doing really well or have in place for the outcomes to be achieved.
- **Indicators** (how do we tell we are making progress in each of the critical success factors).
- **Strategies** (what we need/want to do over the next five years).
- **Implementation** – actions to implement the strategies.
- **Recommendations** – short term needs.

Following the workshop, the project leader and Iraqi participants refined the plan for submission to the Iraqi National Jasmine Whitefly Committee.

Workshop process

The workshop participants worked in small groups and used a card-based visualisation process for reporting and discussion. The cards used for reporting were pasted onto flipchart paper and displayed on walls for the duration of the workshop to facilitate constant reference to the output of previous sessions. The notes on these cards were typed and used by the participants to produce the main components of the plan. This approach enabled the circulation, feedback, editing, emendations and finalization of ideas. All the participants contributed. The mix of formats – open forums and small groups enabled those delegates that were less comfortable in contributing in large groups to contribute to the small group discussion.

National Strategic Plan

The plan comprises a five year strategy with critical success factors, indicators, and strategies and an implementation plan, with actions for each strategy. Short-term recommendations have been made for each critical success factor and are actions that can be taken independent of the situation in Iraq. It has been formally accepted by the Iraqi Government.

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

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 30/06/2007 (Project extended from 01/07/2004 to 30/06/2007)
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 dahl). 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 (01/07/2005-30/06/2006)

Despite a difficult year with the unsettled political situation consequent upon the Maoist activity, significant progress in most of the 6 defined objectives has been made. This is thanks largely to the combined efforts of NARC staff. The completion of the project objectives can be achieved in 2006/07

1) Disease screening and agronomic control packages

Disease screening both for wilt and Stemphylium blight was largely successful in 2005/06 and comprised a major part of the program. Particularly encouraging was the fact that a number of selections had tolerance of both diseases. These included ILL 6811, ILL6256, ILL7164, ILL8093 and ILL6408. The fact that lines like ILL7982 which were selected for farmer participation on the basis of wilt and Stemphyllium did not perform as well in 05/06 trials, strongly indicates the need for several years of data before final conclusions can be drawn on disease resistance. Nevertheless the results and associated yield and seed quality data will continue to be the main criteria for introduction in to the farmer participatory research. In the different regions of Nepal farmer participation has been a feature of NARC activities and one strongly encouraged by ICARDA. In all more than 250 farmers in the various regions received seed samples or participated in NARC trials. Lines like ILL 7723, ILL7164, ILL7982, ILL7537 ILL4402 and ILL7979 have all been distributed to farmers in the Terai - Central, East and West and the Mid Hills regions. Cases for formal registration of new lines are to be considered prior to next planting season. Already one new cultivar, Shital, has resulted directly from the program.

Associated with the disease screening were trials based on plant density and time of planting which proved to have little impact on disease incidence. Fungicide application however proved effective in reducing disease incidence in a susceptible commercial cultivar, Simal. Depending on the cost and availability of herbicides it seems 2 sprays can be an economic action. However, widespread use amongst the small farmers is not anticipated in the immediate future because of cost and problems of distribution.

2) Lathyrus low ODAP lines

Lathyrus lines were grown in Perth as an F 4 population. Growth vigor and maturity were assessed. After testing for the neurotoxin ODAP only low ODAP lines are forwarded to Nepal for field evaluation. Pale flower colour which can be used as a marker has also been selected in Perth and 28 F4 lines will be forwarded to Nepal for row evaluation in 06/07. Seed increase as F5 lines of all lines will be conducted in Perth during 2006 to ensure adequate seed supplies for further bulking by NARC. The F4 population in Nepal failed in 2005 – a combination of drought and herbicide drift.

3) Inoculant systems for acid soils

The difficulty in gaining frequent access to acid soil sites in the West of Nepal, has seen these trials deferred until 2006.

4) NARC In-service training and data presentation

A follow up course on statistical analysis was planned to be located in Nepal, but due to DFAT travel warnings this had to be deferred until next season when it is to be hoped security will be improved. The course planned has been successfully undertaken by Dr Jens Berger in the past and has involved some 20 Nepalese scientists. He is happy to undertake the course which is now scheduled for early 2007.

The project supported 5 delegates to the international Grain legume conference in New Delhi at which two poster papers and two posters were presented.

5) Linkage with ICARDA specialist

ICARDA lentil breeder Dr Ashutosh Sarker has remained in close contact with NARC scientists both through the International Grain Legume Conference in New Delhi and a visit to the country in January 06. During his visit he examined the farmer participation trials in the Mid hill and inner terai (Rampur). Some 40 new line were made available from his breeding program for assessment in Nepal. These were evaluated for the first time at Rampur in seed increase rows.

6) Project administration, communications and publications

NARC staff have fully documented their results despite the number of administrative changes. The return to Nepal of Dr Renuka Shrestha after her successful PhD studies considerably strengthens the NARC team after a series of administrative changes at NARC.

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

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 38969468 Fax: 07 38969533 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 (eg. pathogenesis-related proteins, phytoalexins) and physical (eg. 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 progress

Year 4 (01/07/2005-30/06/2006)

Objective 1. Host defence mechanisms in mango fruit (Sri Lanka, the Philippines and Australia).

Field trials to evaluate the efficacy of defence activators for postharvest disease control in mango were conducted in Australia (North and South Queensland) and the Philippines. In North Queensland, KasilR (potassium silicate) applied as a soil drench and BionR (acibenzolar-S-methyl) applied as a foliar spray significantly reduced the incidence of stem-end rot and total postharvest disease in 'R2E2' mango fruit.

Reductions in anthracnose by these treatments were not statistically significant this season. There were also no significant reductions in postharvest disease levels in 'Kensington Pride' (KP) mangoes by defence activator treatments at both the North and South Queensland field sites, although there was an encouraging trend of reduced anthracnose by two silicon treatments at one field site in south Queensland. Variability in the response of mango to defence activator treatments may be related to timing and method of application, soil type and regularity of flowering/fruit set. In the Philippines where trials were conducted on 'Carabao' mango at two field sites (Site 1: Davao del Sur, relatively dry mango production area and, Site 2: Davao del Norte, relatively wet mango production area), BionR significantly reduced postharvest anthracnose, blossom blight and scab at site 2. Scab was also reduced by BionR at site 1. KasilR and rice hull ash (a mulch containing over 60% silica) reduced anthracnose and blossom blight under certain conditions at site 2. Follow-up trials are planned for Australia, the Philippines and Sri Lanka for the next mango season.

In Sri Lanka, desapping mango fruit significantly reduced both anthracnose and stem-end rot in two local cultivars, confirming results from last season. Desapping 'KP' mangoes in Australia however did not reduce disease, which contrasts with results obtained in Australia last year. Fruit in the current season were very mature with low volumes of sap, which may account for the different result. A further trial to investigate the effect of maturity and desapping on postharvest disease in 'KP' mango is planned for the 06/07 mango season in Australia.

A selection of Sri Lankan mango cultivars of differing susceptibility to postharvest disease (anthracnose and stem-end rot) were analysed for chitinase activity in sap, sap volumes and galloyl tannin levels in peel. Peel samples have also been extracted for resorcinol analysis. Results obtained to date indicate some correlation between galloyl tannin levels and anthracnose resistance, although one highly susceptible cultivar did have high levels of galloyl tannin. Results of resorcinol analyses will provide more information when they become available.

Objective 2. Host defence mechanisms in banana fruit (Sri Lanka).

Higher levels of total soluble phenolic acids, free phenolic acids, glycosidically-bound phenolic acids, ester-bound phenolic acids and cell wall-bound phenolic acids were found in freckle-infected banana peel compared to non-freckled peel. PR-proteins (chitinase and -1, 3-glucanase) were also higher in freckled peel.

Elicitors were separated from cell wall extracts of *Phyllosticta musarum* (freckle pathogen) and *Colletotrichum musae* (anthracnose pathogen) using gel filtration chromatography and resulting fractions were screened using a banana petiole bioassay. Fractions eliciting the strongest defence responses were then identified for further investigation. The elicitor of *C. musae* was found to be a protein whereas that of *P. musarum* contained glycoproteins. Further purification and characterisation of these are continuing.

Anthracnose development was lower in banana cultivars which had relatively low peel pH (ie. below 5.5) during ripening. In liquid culture *C. musae* increased pH levels of the growth medium by secreting ammonia. The data suggests that in certain cultivars mechanisms may exist to counter pathogen-induced pH changes.

A field trial was conducted to evaluate the defence activators BionR, salicylic acid and K2HPO4. While results are still being analysed, there are promising indications that treatments reduced anthracnose and crown rot.

Objective 3. Research capacity enhancement (Sri Lanka and Australia).

Two industry training workshops were held in Sri Lanka in October 2005. The 2-day workshops were designed to instruct participants and improve postharvest handling capacity in Sri Lanka. The topics covered included production issues, numerous aspects of postharvest handling, quality and supply chain management. Field visits were also included to see vegetable production and harvest first hand. The first workshop, '*Postharvest Handling of Fruits and Vegetables'* was held at the Postgraduate Institute of Science, University of Peradeniya. The target group was researchers, academics, industry personnel and others possessing sufficient background knowledge. The second workshop, '*Postharvest Handling of Cut Flowers and Vegetables'* was held in Nuwara Eliya and was attended by growers, sellers, researchers and industry personnel. Both workshops were highly successful and well attended.

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

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, and
- 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 (eg 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 progress

Year 2 (01/07/2005-30/06/2006)

Despite the logistical difficulties and the difficult security situation in some parts of Afghanistan, the project "Wheat and maize productivity improvement in Afghanistan" is progressing successfully towards its purpose thanks to its research, extension, and formal and informal capacity building activities.

In collaboration with researchers in the Agricultural Research Institute of Afghanistan (ARIA), 126 promising wheat and maize varieties have been identified, 6 of which are potential candidates for official release nationally. Such research lacks value unless its results are disseminated promptly and effectively. 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, and in some instances farmers are making the case that they provide an alternative to illegal practices. 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. The gross margin of the double cropping wheat based system is still inferior when compared to poppy mono-cropping. However farmers mention that the inherent risk of seeing their poppy crop destroyed by the authorities make a viable wheat–maize rotation interesting. We are obviously not claiming that this is a unique response to poppy cultivation in the country, but present it as part of a possible solution.

Finally, the project contributes effectively to an evident improvement of the institutional and individual capacity of our partners. We are making good progress towards our aim of developing a strong core team of well trained national scientists working in the public, private and NGO sectors.

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

Overseas Collaborating Countries	Iraq
Commissioned Organisation	International Center for Agricultural Research in the Dry Areas, Syria
Project Leader	Dr Colin Piggin Phone: +963-21 2213433 Fax: +963-21-2213490 Email: c.piggin@cgiar.org
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, and
- introducing, evaluating and selecting improved germplasm for adaptation to rainfed farming systems in northern Iraq.

Project progress

Year 1 (01/05/2005-30/04/2006)

The implementation of the project has been and remains difficult given the political and security situation in Iraq. There have been changes in MOA Minister (twice) and MOA Coordinator, a referendum and election, and land disputes and security concerns, which have meant that no planned activity has been possible in Tel Afar and Al Rashidya research stations. The MOA project co-ordinator, Dr Awad Abbas, DG of the State Board of Agricultural Extension was assassinated in Baghdad after returning from the September 2005 planning meeting at ICARDA, which was a severe setback, although his replacement, Dr Saleh Bader, DG of the State Board of Research, is providing excellent support. 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 commencement on 1 May 2005. 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 have been two major planning meetings at ICARDA in July and September 2005, which were well attended by Baghdad, Mosul, ICARDA and Australian scientists. A major baseline survey of 260 farm families has been undertaken and is being analyzed and evaluated by University of Mosul, MOA Baghdad and ICARDA socio-economists, the former introduced as collaborators after the project commenced. The Ninevah Implementation Committee, set up by MOA to manage the project, has met and produced minutes from 18 meetings which discussed and coordinated the Iraqi activity. The agreed workplan for the demonstration program has been carried out at 13 locations in the four main agroclimatic zones as planned. However, because of heavy rain, security concerns, land disputes and transport shortages, it was only possible to undertake 30 of the 80 planned research trials evaluating better adapted lines/varieties. The agreed training program at ICARDA for 23 Iraqi scientists was exceeded. Capital purchase of zero-till seeders was completed and seed cleaning plants are under way. Operational funds were transferred to all partners. This is detailed below.

Activities were initiated and facilitated through three 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 June 2005 with ICARDA scientists, in July 2005 with ICARDA and Iraq scientists, and in September 2005 with ICARDA, Iraqi and Australian scientists. Much of the discussion was based on previous experience by collaborators in Iraq and in similar environments in north-east Syria.

To provide background and a base for future impact assessment, a baseline survey was developed and conducted with 260 farmers in July/August 2005 by MOA and University of Mosul socio-economists, which characterized the dryland environments and farming systems in Ninevah and identified constraints. Preliminary results were collated and presented at the September 2005 planning meeting to help guide selection of crop varieties and technologies for testing/promotion.

Varieties and technologies of interest identified in these meetings and the baseline survey were incorporated into a detailed 2005/06 workplan prepared at the September 2005 meeting, which formed the basis of trials and demonstrations undertaken in 2005/06. ICARDA and Australia provided seed for trials and demonstrations based on this evaluation and workplan.

On-farm demonstrations of improved 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, Al Namroud
- Low Rainfall Areas: Tel Abta, Al Hadar, Al Mahlabiah
- Supplementary Irrigation: Rabiah, Al Namroud, Humeydat

Best-bet technologies and new lines/varieties were tested and demonstrated at these sites in a participatory manner with farmers. Experiences were also promoted more 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 through distribution of seed from the demonstrations/trials to interested farmers for planting in 2006/07.

Planned demonstration trials on crop management issues such as tillage (farmer practice *vs* modified tillage), fertilizers (recommended and reduced rates of N and P), weed control (plus and minus herbicides) were not conducted because of heavy rain, security concerns, land disputes, lack of machinery and transport shortages; it is planned to conduct them in 2006/07.

Research trials evaluating better adapted lines/varieties of the project crops were planned at ten locations: Rabiah (HRA), Al Kosh (HRA), Al Rashidya (MRA), Baashika (MRA), Telkeyf (MRA), Al Namroud (MRA), Bartala (LRA), Al Hadar (LRA), Tel Abta (LRA), Tel Afar (LRA). However, it was only possible to conduct 30 of the planned 80 research trials as listed below. Many trials could not be established because of heavy rain, security concerns, land disputes and transport shortages. This was disappointing although the plan was very ambitious; it is planned to conduct them in 2006/07.

- Wheat: 6 of 14 planned durum/bread wheat experiments conducted at Al Rashidya research centre
- Barley: 5 of 17 planned experiments conducted at Al Rashidya and Al-Hadar
- Chickpea: 14 of 16 planned research experiments conducted at Al Rashidya, Bartala and Al-Kosh
- Lentil: 4 of 8 planned experiments conducted at Al Rashidya and Bartala
- Faba bean: 1 of 9 planned experiments conducted at Al Rashidya
- Forage legumes: 16 forage legume experiments could not be planted because of heavy Jan-Feb rains.

In project-linked research at ICARDA, a range of varieties/lines of oats, peas, canola and other oilseeds (*Brassica napus, B. juncea, B. carinata, B. rapa, camelina sativa, C. abyssinica, Sinapis alba, Linum usitatissimum*) 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 was collected for broader testing of material of interest in Iraq and ICARDA in 2006/07.

Demonstrations and trials have been harvested and measured and data collected, analyzed and evaluated. Reports are being prepared and will be presented at the September 2006 annual reporting/planning meeting at ICARDA.

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 other visits by MOA/DOA scientists to discuss and plan project activities. Australian collaborators presented four seminars in the September 2005 planning meeting on advances of relevance to Iraq in cereal and legume improvement, crop management and crop-livestock interactions in Australia.

Lists of priority items for capital purchase were discussed and developed between MOA and ICARDA according to the agreed budget. Four zero-till seeders from India were purchased, with three sent to DOA Mosul in May 2006 and one kept at ICARDA for project research and training. Specifications and prices for high-priority seed cleaning equipment were obtained – MOA/DOA are still considering the most appropriate machines for purchase.

There were major delays with dispatch of the budget to Iraq. Fortunately, fund transfer delays did not affect technical progress and the extensive 2005/06 demonstration and research programs were implemented with a special allocation of funds from MOA, support with fertilizers and time/money from farmers, and willing contributions of vehicles and time from DOA staff. The fund transfer issue was eventually solved and the first-year Iraq operational funding was transferred to the MOA Baghdad Bank in June 2006.

Concluded projects

1 July 2005 – 30 June 2006

India

Bilateral

FIS/2005/176: Masterclass - Aquatic animal health

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
Collaborating Institutions	
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 aqaculture in some developing countries is providing an important source of protein to supplement otherwise meager 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 south-east Asia and Pacific Island countries will offer comprehensive training in the following aspects of grow-out aquaculture nutrition: Principles of Aquaculture Nutrition; Introduction to Diet Formulation; Pelleting and Estrusion 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 will be presented as lectures, practical laboratory tutorials, discussion and revision sessions with field trips to farms and feed mills. Course material will include 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 7-19 August 2006. The two week live-in intensive course for 27 invited participants from 10 south-east Asia 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 cover 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 organizations 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 meager 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 utilizing locally available agricultural ingredients.

FST/1995/106: Improving and maintaining productivity of eucalypt plantations in India and Australia

Overseas Collaborating Countries	India
Commissioned Organisation	CSIRO Forestry and Forest Products, Australia
Project Leader	Dr Daniel Mendham Phone: 08 93336663 Fax: 08 93878991 Email: Daniel.Mendham@ensisjv.com
Collaborating Institutions	Kerala Forest Research Institute, India University of Western Australia, Australia University of New South Wales, Australia Griffith University, Australia Center for International Forestry Research, Indonesia
Project Budget	$1,869,376
Project Duration	01/07/1997 to 31/12/2005 (Project extended from 01/07/2002 to 31/12/2005)
ACIAR Research Program Manager	Dr Russell Haines

Project background and objectives

Short-rotation tree plantations are recognised as a fast way to grow timber, whether softwood or hardwood. Trees may be planted into areas of felled forest as well as planted or sown into pasture lands. In Australia, both kinds of plantation are productive, with annual growth rates of eucalypts up to 30 m3/ha in southwest Australian pastures. In India, however, despite experience with eucalypt plantations over the last 150 years, growth rates are poor (5-10 m3/ha/yr) and declining. Nutrition is seen as the key to maintaining or improving growth.

Natural forests do not appear to be nutrient deficient; native tree species and their associated understorey vegetation and soil micro-organisms use and recycle the inherent soil fertility efficiently. When trees are harvested, however, the tree-soil cycle is broken and nutrients are removed, depleting the soil reserves unless there is continuing re-supply, from added fertilisers, or from microbial breakdown of surface and soil organic matter.

The project is working with researchers at India's Kerala Forest Research Institute and at the CSIRO Centre for Mediterranean Agriculture to measure and model the growth, development, nutritional status and physiology of young eucalypts in response to management treatments and climate. In addition to the work on eucalypts, scientists will analyse changes in soil nutrient and organic matter to depths of one metre, and measure soil water storage above the watertable.

Project outcomes

The overall objective of this project, located in Kerala, India and in Western Australia, was to identify and develop practices for manipulating soil organic matter, and soil and tree nutrient and water status. This forms the basis for implementing silvicultural regimes that optimise conservation and use of site resources and enable sustainable wood production from eucalypt plantations.

A final review of the project found that it had been successful within the limitation of a five-year time frame. Improved establishment techniques resulted in stimulating early growth to mid rotations. Initial economic analyses indicate an internal rate of return of 20% from best treatments. Strategic process-related research on stand and soil nutrient economy has provided sound insights into the operation of these processes and their dynamics. However data are needed from a full rotation (7 years) to enable simulation with a degree of confidence.

The project has gathered much practical information on the use of fertilisers, weed control and ground cover planting with eucalypt plantations, and demonstrated the differential responses of species over different sites. In particular it has been able to quantify responses to treatments, which allow economic analyses that can inform management decisions. At this stage of the rotation there appeared to be no response to retention of slash from the previous rotation, and to nitrogen-fixing groundcovers, contrary to expectation from research elsewhere, although this may change further into the rotation. The research has produced a better scientific understanding of the dynamics of fertiliser response in this climate and on these soils, including the role of soil organic matter in the nutrient cycling.

The training/capacity building component of the project has been particularly successful with an obvious increase in the skills of the KFRI team in field experimentation and laboratory techniques.

ADP/2005/041: Trade and agricultural development in developing countries - China, India

Overseas Collaborating Countries	China, India
Commissioned Organisation	International Food Policy Research Institute, Market and Structural Studies Division, USA
Project Leader	Dr Ashok Gulati Phone: 1 202 862 5600 Fax: 1 202 467 4439 Email: a.gulati@cgiar.org
Collaborating Institutions	
Project Budget	$150,000
Project Duration	01/06/2004 to 31/12/2005
ACIAR Research Program Manager	Dr Ray Trewin

Project background and objectives

Assessing agricultural policies and levels of protection or disprotection for selected Asian developing countries, particularly India and China, since the inception of the WTO Uruguay Round negotiations in 1985, will help refine approaches to ensuing WTO benefits agriculture. The conceptual and empirical issues that arise when calculating such measures as market price support (MPS) or producer support estimates (PSEs) for developing countries need to be more clearly understood. Two reports have been produced (Mullen, Orden and Gulati, Agricultural policies in India: PSEs 1985-2002, http://www.ifpri.org/divs/mtid/dp/papers/mtidp82.pdf; Cheng and Orden, Exchange rate misalignment and its effects on agricultural PSEs: empirical evidence from India and China, http://www.ifpri.org/divs/mtid/dp/papers/mtidp81.pdf).

The results presented in the two papers have increased knowledge about the policies that have caused protection or disprotection of agriculture in India and China, and the magnitudes of these effects. The results have been presented at conferences in China, Pakistan, at FAO, and at meetings of the American Agricultural Economics Association, and will be presented in other professional settings and in discussion with policy-makers.

Project outcomes

Final report is forthcoming as at October 2006.

Pakistan

Bilateral

PLIA/2005/159: A constraints analysis of mango supply chain improvement in Pakistan

Overseas Collaborating Countries	Pakistan
Commissioned Organisation	University of Queensland, Australia
Project Leader	Associate Professor Ray Collins Phone: (07) 5460 1328 Fax: (07) 5460 1324 Email: ray.collins@uq.edu.au
Collaborating Institutions	
Project Budget	$108,455
Project Duration	25/03/2006 to 31/05/2006
ACIAR Research Program Manager	Dr Jeff Davis

Project background and objectives

In Pakistan the production of fruits and vegetables is not fully utilised, and after domestic consumption a major part of the crop is wasted. Yet its horticultural sector is significant for domestic production and also for export, mainly to markets in the Middle East, Europe and other Asian countries. Problems include a lack of infrastructure, few storage and processing facilities, along with poor market intelligence and communication. An improved understanding of the system from grower to domestic and export markets would boost utilisation and prevent waste. Identifying and analysing the constraints of supply chains for mangoes would help Pakistani mango growers receive increased value from their produce. This research sought to identify these constraints and associated impediments in representative supply chains and to provide recommendations for future research.

Project outcomes

The project achieved its objectives, identifying the various components of the representative supply chains for mangoes in Pakistan and recording associated impediments and constraints. In addition to providing a scope for a subsequent supply chain project, this stand-alone small research activity provided valuable information on existing supply chains in Pakistan. This was of benefit in developing the three-year project associated with the Australia-Pakistan Agriculture Sector Linkages Program (HORT/2005/157 *Optimising mango supply chains for more profitable horticultural agri-enterprise in Pakistan and Australia*). It also provided useful data for the development of HORT/2005/160 *Increasing citrus productivity in Pakistan through improved orchard management techniques and more efficient use of inputs.*

Other South Asia

Bilateral

HORT/1997/101: A survey of fruit flies in Bhutan and a field control program for Bactrocera minax (Enderlein) (the Chinese citrus fly)

Overseas Collaborating Countries	Bhutan
Commissioned Organisation	Griffith University, Faculty of Environmental Sciences, Australia
Project Leader	Professor Dick Drew Phone: 07 3875 3696, home 07-3379 1554, mobile 0417 729 356 Fax: 07 3875 3697, home 07 3379 1554 Email: D.Drew@griffith.edu.au
Collaborating Institutions	Ministry of Agriculture, National Plant Protection Centre, Bhutan
Project Budget	$295,178
Project Duration	01/01/1999 to 30/06/2006 (Project extended from 01/01/2001 to 30/06/2006)
ACIAR Research Program Manager	Mr Les Baxter

Project background and objectives

Recent field surveys in Bhutan have revealed that between 50 and 100 per cent of citrus crops have experienced losses due to the fruit fly *Bactrocera minax* (Chinese citrus fly). However, it is also possible that crop losses are due to a complex of pest fruit fly species with the presence of the Oriental fruit fly and the melon fly. This project is conducting a fruit fly survey to identify pest species to define which of those species are causing crop losses. In addition, scientists are developing techniques for using protein bait sprays and instructing local personnel in the identification of fruit flies and application of bait sprays.

Project outcomes

Final report is forthcoming as at October 2006.

Projects under development

1 July 2005 – 30 June 2006

India Bilateral

CIM/2005/020	Molecular marker technologies for faster wheat breeding
PLIA/2005/013	PLIA Projects - balance available
PLIA/2006/132	Happy seeder policy analysis in India and Australia
PLIA/2006/135	Trends in world agriculture to 2030 in India, China and Indonesia
SMCN/2006/071	Root system traits to improve grain yield and drought resistance of wheat in Australia and India
SMCN/2006/072	Impacts of watershed development on catchment hydrologic response and economic benefits in Andhra Pradesh, India
SMCN/2006/073	Application of seasonal climate forecasting to improve ground-nut production in drought prone districts of Andhra Pradesh, India
SMCN/2006/094	Enhancing profitability of wheat-based farming in NW India by improving grain quality
SMCN/2006/124	Fine-tuning the Happy Seeder technology for adoption in NW India
SMCN/2006/158	Analysis of institutional arrangements underpinning rational water resource management and watershed development in Andhra Pradesh, India

India Multilateral

ADP/2006/145	Impact of changing agricultural markets on small-farm participation and poverty: Cases from India, Vietnam, and Indonesia

Pakistan Bilateral

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 productivity in Pakistan and Australia through improved orchard management techniques
LPS/2005/132	Improving dairy production in Pakistan through improved animal nutrition and enhanced milk collection systems
LPS/2005/162	Constraints analysis of the Pakistan dairy industry
LPS/2005/164	Sourcing and transfer of dairy cattle germplasm to Pakistan
PLIA/2006/136	Policy analysis of the dairy and mango industries in Pakistan and implications for adoption of research outcomes
SMCN/2005/144	Optimising canal and groundwater utilisation to assist water users associations in maximising crop productivity and managing salinisation in Pakistan and Australia

Bangladesh Bilateral

SMCN/2005/001	Addressing constraints to pulses in cereals-based cropping systems, with particular reference to poverty alleviation in north-western Bangladesh
SMCN/2005/146	Expanding the area for Rabi-season cropping in southern Bangladesh
SMCN/2006/090	Implementation of integrated disease management for chickpeas in Bangladesh

Bangladesh Multilateral

SMCN/2006/177	Diversification of cropping systems in Bangladesh by improving and expanding lentil production

Other South Asia Bilateral

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

India consultations

10–11 September 2001

ACIAR has a formal program of consultations with India to establish priorities in research collaboration. The most recent consultation was held in September 2001. Some of the identified priorities are listed below, and the priorities are detailed more fully at www.aciar.gov.au under Partner Country Priorities/India.

In 2004–05 the program is continuing to emphasise agricultural policy, crop production and management, broad-scale land and water resources management, and livestock nutrition. Current priorities in these areas are:

Agricultural economics and development policy

- Institutional policies to promote equitable and efficient water use (pricing, systems, organisations etc.)
- Implications of WTO and globalisation issues (subsidies, cropping pattern changes, income distribution, employment, price volatility) for the equitable use of land and water resources for agriculture
- Natural resource management economics studies emphasising quantification of externalities in land and water use and approaches for equitable use of common property
- Research to improve the efficiency of marketing and trade of livestock products and processed foods.

Crop sciences

- Management of abiotic constraints to production, especially drought, salinity and enhancement of water-use efficiency
- Improved crop management, including enhanced crop establishment, increasing factor productivity and diversification of cropping systems through new crops and rotations.

Animal sciences

- Efficient utilisation of crop residues and new opportunities for feed production
- Improved ruminant feeding strategies, including supplementation of rations, and treatments to improve digestibility and nutritive value
- Sustainability of inland fisheries (including use of saline waters) for aquaculture.

Land and water resources

- Increased water use efficiency, and utilisation of waste waters
- Integrated and equitable management of watersheds through enhanced rainwater harvesting and water storage and related institutional issues
- Improving soil quality through crop residue management, integrated nutrient management and overcoming subsoil constraints to productivity
- Remediation of contaminated sites through cropping and ameliorating soil salinity arising from irrigation.

Relevant ACIAR publications

This list is a selection of titles from ACIAR's range of scientific publications that are relevant to South Asia's agricultural research and development sector. Hard copies are available by emailing comms@aciar.gov.au, or may be requested through ACIAR's South Asia office. Publications may also be downloaded from ACIAR's website, www.aciar.gov.au.

Impact Assessment Series Reports

02 Increased efficiency of straw utilisation by cattle and buffalo (1998)
06 Pigeonpea improvement (1998)
16 Control of footrot in small ruminants of Nepal (2001)
25 Genetics of and breeding for rust resistance in wheat in India and Pakistan (2004)
35 Review of the returns to ACIAR's bilateral R&D investments (2005)
39 Benefits to Australia from ACIAR-funded research (2006)
40 Zero tillage for weed control in India: the contribution to poverty alleviation (2006)

Monographs

32 Working with mycorrhizas in forestry and agriculture (1996)
34 Breeding for resistance to infectious diseases in small ruminants (1995)
36 Ruminant nutrition and production in the tropics and subtropics (1996)
37 Detection and treatment of mineral nutrition problems in grazing sheep (1996)
50 Saline agriculture for irrigated land in Pakistan (1998)
54 Survey toolbox for livestock diseases: a practical manual and software package for active surveillance in developing countries (1999)*
56 Bibliography of trees, shrubs and grasses for saltlands (1999)
57 Haemorrhagic septicaemia (1999)
61 A visual guide to nutritional disorders of tropical timber species: *Swietenia macrophylla* and *Cedrela odorata* (2001)
60 Biological control of water hyacinth (1999)
74 Nutrient disorders in plantation eucalypts (2nd edn) (2001)
79 Biological control of water hyacinth vol. 2 (2001)
82 Controlling Newcastle disease in village chickens: a field manual (2001)
83 How to unravel and solve soil fertility problems (2002)
86 Controlling Newcastle disease in village chickens: a training manual (2002)
87 Controlling Newcastle disease in village chickens: a laboratory manual (2003)
97 Effects of globalisation and economic development on the Asian livestock sector (2003)
100 Field methods for rodent studies in Asia and the Indo Pacific (2003)
102 Lantana: current management, status and future prospects (2003)
111 High-yielding anthracnose-resistant *Stylosanthes* for agricultural systems (2004)
114 Diversity and management of Phytophthora in Southeast Asia (2004)
115 Nitrogen fixation in acacias (2005)
119 Guidelines for surveillance for plant pests in Asia and the Pacific (2005)
121 Planters and their components: types, attributes, functional requirements, classification and description (2006)

Proceedings

42 Productive use of saline lands (1993)
57 Leucaena: opportunities and limitations (1994)*
66 Bluetongue diseases in the Asia-Pacific region (1996)
70 Management of clay soils for rainfed lowland rice-based cropping systems (1996)
84 Sandalwood and its products (1998)
85 Seeking agricultural produce free of pesticide residues (1998)
88 Towards better management of soils contaminated with tannery waste (2000)
97 Hypsipyla shoot borers in *Meliaceae* (2001)
111 Eucalypts in Asia (2003)
112 Breeding for drought resistant peanuts (2003)
114 Modelling nutrient management in tropical cropping systems (2004)

Technical reports

08 New technologies for rainfed rice-based farming systems in the Philippines and Sri Lanka (1988)
17 Rice production in Sri Lanka: a combined agronomic/economic study in the intermediate and dry zone (1990)
49 *Chukrasia*: biology, cultivation and utilisation (2000)
53 Cooperatives: issues and trends in developing countries (2003)
59 Using seasonal climate forecasting in agriculture: a participatory decision-making approach (2004)

Working Papers

34 Research capacity and general community impacts of five ACIAR-sponsored projects
35 Poverty alleviation through agricultural research: the ACIAR experience
39 The dual approach to research evaluation: a simplified empirical illustration
44 Defining practical guidelines for evaluating long-term, smallholder decision-making in developing countries
52 Watershed Management for Water Quality Improvement: the role of agricultural research
56 Agricultural Research and Poverty Alleviation: Some International Perspectives
62 Report on a review of ACIAR-funded projects on Rhizobium during 1983-2004