Country Profile

South Asia

December 2004

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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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 1 December 2004. There were 26 bilateral and 4 multilateral projects, the latter being led by an international agricultural research centre. As well, 9 new projects (7 bilateral and 2 multilateral) were under development, many of which are expected to start in the next 12 months.

This publication also sets out the key outputs from 11 bilateral and 5 multilateral projects that have been completed since July 2002.

As well as these project summaries, the publication includes extracts from ACIAR's 2003–04 Annual Report covering South Asia, our near-term program as outlined in the 2004–05 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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December 2004

South Asia Reports 2003–04

(extracts from ACIAR Annual Report 2003–04)

India

Active projects in 2003–04	24
AOP budgeted expenditure in 2003–04	$2,522,606
Actual bilateral country expenditure in 2003–04	$2,482,097
Bilateral country expenditure in 2002–03	$2,398,203
Bilateral country expenditure in 2001–02	$2,080,586

Key performance indicators	Performance 2003–04
• At least three-quarters of new projects emphasise northern or central India	• Eight of 11 projects commenced or under design during 2003-04 focus on northern or central India
• Completion of independent analysis on effects of adoption of reduced tillage practices on poverty in Haryana and Punjab	• Analysis of impacts on poverty is underway and awaiting necessary data from India
• Evidence that ACIAR training courses have led to better design of experimental trials of crop genotype performance in different environments	• Two courses were run in 2003, with 28 participants, more than 75 per cent of whom reported that course objectives had been met
• Farmers in Gujarat purchasing protected nutrient livestock feeds produced on a commercial basis	• The protected-feed mill is running at full capacity with all feed sold on a commercial basis. A second plant is being constructed

Position

ACIAR engages in projects with India that emphasise sustainable smallholder production, along with the management of scarce water and nutrient resources. Productivity of crops, livestock and aquaculture that will raise farmer incomes remains a priority. Recent research has assisted the adoption of minimal tillage approaches in rice–wheat farming systems, with significant benefits from moisture conservation and weed management in crops. India has a large and well-developed national agricultural research system that has collaborated strongly in ACIAR projects. Additional linkages with groups such as State Agricultural Universities, the National Dairy Development Board and technical NGOs have facilitated technology development and the delivery of benefits. In September 2003 the Government of India released new policy guidelines for bilateral donors, requesting the development of jointly funded and focused projects on areas of mutual, high priority. This will also result in a greater emphasis on working with independent research organisations and NGOs, but will still aim to deliver benefits to farmers and to assist with policy development for India's poorest regions, mainly in north and central India.

Achievements

Water resource management is vital to India. A project that reviewed water institutions involved in irrigation resourcing and water allocations highlighted the most successful management strategies. The review led to a **framework for assessing successful management practices** in consultation with key Indian stakeholders. A study of degradation and desertification of arid rangelands is seeking to determine the cause of these problems. Using GIS mapping and ground-based surveys, large amounts of data have been collected and collated. These outcomes are being disseminated through discussions with village communities and relevant administrators, and researchers are also advising on how to prevent further problems.

Improving the productivity of sheep in Maharashtra continues. The Booroola gene has been found responsible for higher than average levels of multiple births in one breed of local sheep. Cross-bred **varieties incorporating the Booroola gene** are being produced and distributed to local shepherds' flocks for testing in the field. Results to date show the introduction of the Booroola gene through both rams and ewes results in progeny inheriting the gene, offering the chance for increased multiple births.

Treating cattle with a fungal inoculum can aid digestion in the rumen, increasing the uptake of benefits from consuming fibre. Special nutrients are added to the feed to encourage growth of the fungus. One fungus-specific nutrient trial that also added sulfur supplements has resulted in **increased feed intake** and better rumen function. Supplemental urea ensured complete utilisation of sulfur, further boosting rumen performance. Trials are now planned to determine if milk production has been enhanced.

Another project has examined the role of feed supplements, making increased protein and fat available in cattle diets. A factory producing these supplements was opened late in 2002, and trials since then continue to show **cattle fed the supplement produce more milk, offering a boost to smallholders' incomes**. This represents an increase in disposable income of between 30 and 70 per cent depending on the breed of cattle. Use of the supplement has also spread to other regions, where similar rises in milk production have been reported.

Salt used in tannery processes contaminates soil after disposal of tannery effluent. Salt preserves the hides, but other methods are being developed based on drying and using additives instead. To date these have **proven as effective as salt**, and industry trials are now planned. Recycling and reuse of tannery materials are also showing promise of reduced salt waste. This approach has no ill effects on leather for up to 100 cycles.

The use of ***Stylosanthes*, a tropical legume species**, as forage in animal production is common throughout parts of India and China. Varieties with superior agronomic performance to those currently planted and with the added bonus of resistance to anthracnose (the major disease of *Stylosanthes*) have been selected and released in both countries. Studies of pathogenic fungal groups in each country have enabled scientists to determine the genetic structure of the anthracnose causal agent and understand its virulence for the first time. A diverse population of this causal agent has been revealed in China and India, and this will allow more defined use of resistance and matching of varieties to agro-ecological conditions in future breeding and utilisation.

Breeding of chickpea for improved yield and quality traits and drought resistance has produced several crosses with improved characteristics. Glasshouse and initial field trials to **examine physiological performance**, including the ability of plants to adjust water use in drought, have shown promise. Seed yield and quality were also examined, with results influencing selection of improved breeding material.

Disease resistance in chickpea is the subject of a separate project, also focusing on faba bean and lentil. Sources of resistance to diseases (including Ascochyta blight) for all three crops have been identified, and **promising lines are now at the trial stage**. Management practices for faba bean and chickpea, such as the use of varieties tolerant to late planting and wide spacing and use of fungicides, revealed yield increases and some protection against Ascochyta. An integrated disease management package incorporating research from this and previous projects has provided robust control of Ascochyta in farmers' fields near ICARDA, in Syria.

The constraints faced by waterlogged wheat crops have been more clearly identified and understood. This includes the identification of two waterlogging environments and the role of micronutrient concentrations in causing seedling toxicity after waterlogging. Such **information is vital when screening for wheat varieties** suited to these environments. More than 12 wheat lines with tolerance to waterlogging have been added to those already identified. The 'Happy Seeder', a locally designed seeding machine to allow direct drilling of seed (with minimal soil disturbance), has been trialled and refinements adopted. The seeder was developed as part of a project evaluating the use of raised cropping beds for rice–wheat farming systems. Optimal approaches such as seed depth and mulch loads are being determined through trials using the 'Happy Seeder'.

Evaluation of genetic material and management technologies to improve citrus production in Sikkim continues, with trials of a range of germplasm under-way. Citrus varieties with **some level of resistance to huanglongbing** (greening) disease, prevalent in local varieties, are being assessed, and management techniques to improve productivity of existing varieties are being tested.

Aflatoxin contamination of peanuts is being examined in a project to develop low aflatoxin risk varieties. Genotypes showing little or no infection from *Aspergillus flavus*, the fungus which can cause aflatoxin contamination, have been identified and **early field trials indicate the trait may be stable**. Physiological and biochemical mechanisms affecting aflatoxin production and their impact on contamination levels are also being examined. Drought-resistant peanut varieties with average yield

advantages of 20 per cent over currently planted varieties in India's rain-fed and irrigated peanut growing regions have been identified. A new project is developing a two-stage dryer for rice and maize grains in West Bengal. Losses from storage of wet grain significantly hamper the expansion of the grain industry.

Research has shown that **nutrient application and weed control produce the largest growth responses for eucalypts** planted in Kerala State. This knowledge is being incorporated into existing silviculture programs to create more even growth responses for plantations across Kerala. Plantations based on these practices and economic analyses are also being developed to produce optimal results.

Pakistan

Active projects in 2003–04	6
AOP budgeted expenditure in 2003–04	$514,458
Actual bilateral country expenditure in 2003–04	$697,496
Bilateral country expenditure in 2002–03	$212,104
Bilateral country expenditure in 2001–02	$211,617

Key performance indicators	Performance 2003–04
• Major Gemini virus diseases of cotton in Pakistan documented and molecular characterisation of strains completed.	• The cause of cotton leaf curl disease was determined and the role of a small satellite DNA particle in viral recombination identified.
• Construction of test system for saline drain effluent management through serial biological concentration under way.	• The start of the project was delayed until early 2004 because of security issues in 2003.

Position

ACIAR maintains a small program that emphasises management of irrigation and drainage, and associated natural resource management. This includes agriculture and forestry on saline soils within a broader focus on overcoming biotic and abiotic constraints in broadacre crop production. Since late 2001, security considerations have hindered the development of further project work in Pakistan.

Achievements

Field surveys of Gemini viruses have revealed the presence of a small satellite DNA, in addition to the DNA genome of the virus. The presence of this satellite DNA is associated with **a Gemini viral strain that has broken the resistance** of some cotton and tomato varieties to cotton leaf curl virus. The role of this satellite DNA has been linked to the recombination of virus DNA. Two major groups of satellite DNA have been identified and their role in overcoming host resistance and in the spread of cotton leaf curl disease is now being investigated. This knowledge is helping scientists to develop control methods for Gemini viruses and also to breed more stable resistant varieties.

A new project is seeking to further develop the raised bed cropping system. This has already been proven to raise maize yields in maize–wheat cropping systems by up to 50 per cent while also **using a third less water**. Despite these results the system is relatively unknown in Pakistan and work is needed to extend its use. This project is trialling a series of soil management options and machinery to develop 'best bet' technology and management scenarios for permanent raised beds. Groups of farmers are involved to help ensure further adoption.

A new project to **increase options for agriculture in saline environments** has recently begun. Saline effluent is often drained into river systems, polluting these for downstream users. The project is aiming to develop profitable systems for farmers based on saline drainage effluent from irrigated farms. Crop, tree and aquaculture options will all be examined, along with salt-harvesting technology.

Bangladesh

Active projects in 2003–04	5
AOP budgeted expenditure in 2003–04	$293,769
Actual bilateral country expenditure in 2003–04	$276,729
Bilateral country expenditure in 2002–03	$368,485
Bilateral country expenditure in 2001–02	$310,423

Key performance indicators	Performance 2003–04
• Information packages on sources of arsenic contamination in major food crops developed and communicated to local and international NGOs and Government.	• Information packages in local languages have been developed and distributed.
• Impact of botrytis grey mould on chickpea production assessed in major production areas.	• Demonstrations of integrated disease management (IDM) practices with chickpea crops on 100 farms, comparing current farmer practices with IDM are under way.

Position

ACIAR's program in Bangladesh is small, given Australia's relatively limited comparative advantage to deal with this country's rice-dominated agricultural problems. Research focuses on constraints to crop production, utilising collaboration with the International Agricultural Research Centres (IARCs). Donor collaboration is encouraged, and a concluding ACIAR-funded project on analysis of the fate of arsenic from groundwater is the research component of a larger initiative on the arsenic problem in Bangladesh, which is funded by AusAID and several international donors.

Achievements

Botrytis grey mould (BGM) is a major constraint to chickpea production, a vital **source of dietary protein for poor farmers**, in Bangladesh. Current approaches to managing BGM are too expensive for Bangladeshi farmers. Cultures of Botrytis cinerea (the causal agent of BGM) have been collected and are undergoing DNA testing to aid in screening suitable chickpea breeding material. Almost 500 lines have been assembled and testing has already revealed differences in disease reactions. Integrated crop management trials involving farmers have demonstrated yield increases of 20–40 per cent. The use of seed from non-BGM infected areas is one example of the management practices being trialled.

Arsenic contamination of soil and crops in Bangladesh continues to exact a high human toll. Irrigation using groundwater has been revealed as a potential source of arsenic transfer to vegetable crops. Levels of arsenic accumulation in crops have also been determined. Key sites where **arsenic poisonings** have been high have been sampled, including soils and groundwater, to produce a database of accumulations. Tests on the role of organic manures have revealed no changes to arsenic accumulation in crops. The addition of high levels of phosphate has been shown to decrease arsenic accumulations, but low levels of phosphate fertiliser can increase accumulations. Information packages in local languages are being disseminated.

Other South Asian Countries

Active projects in 2003–04	9
AOP budgeted expenditure in 2003–04	$504,428
Actual bilateral country expenditure in 2003–04	$562,575

Key performance indicators	Performance 2003–04
• Implementation of fishery stock management strategies for reservoir fisheries in Sri Lanka.	• An aquaculture capability classification scheme has been developed and validated for seasonal tanks, and is being used to guide Government policy. Strategies are being disseminated through extension materials, and community meetings.
• Adoption of control strategies for citrus fruit flies by agriculturalists in Bhutan.	• Due to a severe outbreak of citrus dieback in 2003 ACIAR agreed to put the project on hold until April 2004, as Bhutanese agriculturalists had to deal with the disease outbreak.

Afghanistan

Active projects in 2003–04	1
Bilateral expenditure in 2002-03	$0*
Bilateral expenditure in 2001-02	$0

* $650,000 in multilateral funding

Position

ACIAR's first multilateral project in Afghanistan provided short-term support to wheat and maize production, wheat being by far the most important crop and maize the third most important. Two decades of war devastated Afghanistan's food-production capabilities and depleted critical seed stocks, leaving the nation heavily dependent on food aid from international donors. Further research initiatives will continue to emphasise improved crop varieties and agronomic management of broadacre crops.

Achievements

ACIAR managed an AusAID-funded project, implemented by CIMMYT, to introduce improved wheat and maize varieties to Afghanistan. Stocks of seed of both grains were severely depleted and destroyed by years of conflict, with surviving varieties poorly suited to local growing conditions. During the project **wheat has been distributed via NGOs to 9000 farmers** in four provinces, along with fertiliser inputs provided by other international donors. These new varieties have yielded up to 5 tonnes per hectare and better, almost double the yield of locally favoured varieties. Thirty-five variety trials and wheat nurseries have been established at six sites. Seed multiplication sites to ensure seed production that will support future crops have also been set up. A new winter wheat variety, Solh-02 ('Solh' means peace), was released. The Darul Aman Research Station near Kabul now supports wheat germplasm nurseries and wheat trials.

Seven varieties of open (naturally) pollinated maize seed, previously identified as suitable for Afghan conditions, were also imported, with 2.5 tonnes distributed to 500 farmers via the Ministry of Agriculture and Animal Husbandry (MAAH) and NGOs in time for the 2003 planting season. Evaluation and multiplication was also undertaken. Promising open pollinated varieties yielding up to 6 tonnes per hectare were identified, and a further 60 elite varieties were trialled at eight sites.

Since mid-2002 Afghan wheat scientist Dr Mahmood Osmanzai has been based in Kabul, and 15 researchers and agronomists from MAAH have attended CIMMYT **training courses** in Turkey and Mexico. In-country MAAH staff received a variety of on-farm training, including instruction on how to undertake surveys to identify yield-limiting factors.

Bhutan

Active projects in 2003–04	1
Bilateral expenditure in 2002-03	$44,145
Bilateral expenditure in 2001-02	$67,575

Position

ACIAR's small program with Bhutan began in 1998. Because of Australia's relatively low comparative advantage, the program will remain very small, with a current focus on pest and disease management.

Achievements

ACIAR's single project in Bhutan was put on hold in 2003–04 due to a severe outbreak of citrus dieback, halting the mandarin fruiting season, and limiting the capacity of the project personnel to trial fruit fly control approaches in the field. The main pest species of fruit fly has been identified and trials to use protein bait sprays to disrupt breeding cycles during the fruiting season have only recently recommenced.

Nepal

Active projects in 2003–04	3
Bilateral expenditure in 2002-03	$188,503
Bilateral expenditure in 2001-02	$175,304

Position

Almost 85 per cent of Nepal's population live in rural areas and the majority of these are involved in agriculture. ACIAR has had a small program of projects in Nepal, with an emphasis on crop production and management, and on some aspects of animal health in the lowland Terai, which has most in common with Australian environments.

Achievements

Efforts to improve quality of lentil, a valuable crop for smallholders who can easily sell produce to Indian markets, have identified the importance of management to improve yields. Seed priming (soaking seeds before planting) has been shown to boost yields considerably, in some cases by as much as 40 per cent. Researchers have undertaken training in breeding and statistical analysis. Extension activities have increased farmer participation, including seed production of promising new lentil varieties for field trials. **Lentil varieties resistant to the fungal disease** caused by Stemphyllium, a major threat to production, were trialled, with resistant varieties showing yield increases up to 33 per cent more than local varieties. The same project also aims to improve lathyrus (grass pea), which is widely grown but potentially toxic. Varieties that have lower levels of toxicity are being sourced.

Sri Lanka

Active projects in 2003–04	4
Bilateral expenditure in 2002-03	382,480
Bilateral expenditure in 2001-02	$159,417

Position

ACIAR maintains a small program with Sri Lanka. 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. Several past project outputs are being used in new Asian Development Bank-funded projects. ACIAR maintains a small program in Sri Lanka. On occasions, ACIAR supports Sri Lankan scientists as specialist advisers to assist in projects in the region.

Achievements

A predictive model for yields of fish in perennial tropical reservoirs, developed in an earlier ACIAR project, has been simplified for use by extension workers in Sri Lanka. The model has been validated, based on **catchment land-use patterns** and using data collected by the National Aquatic Resources Agency. Sixteen reservoirs have been chosen for studies to develop culture-based fisheries, with experiments raising fingerlings and fry underway in three reservoirs. Farmer-made feeds are being used, and initial trials are proving that cage culturing is a viable possibility.

Postharvest diseases of tropical fruits frequently cause more than 20 per cent loss—current methods do not reliably control disease during retail marketing and export, causing reliance on fungicide treatment. Improved strategies for managing losses can be developed by boosting the natural defence factors in fruit. Host defence mechanisms in mango and banana are being characterised, along with defence-boosting treatments on mango. The role of mango sap in disease resistance is being studied with the role of management practices, such as harvesting fruit with longer stems, being assessed for their capacity to reduce sap loss and enhance disease resistance. Facilities at the University of Peradeniya to undertake plant defence research have been upgraded. Natural defensive compounds identified in mango and banana species are now being characterised and investigated.

South Asia Plans 2004–05

(extracts from ACIAR Annual Operational Plan 2004–05)

India

Population	1048 million
GNI per capita	AUD 884

India: Bilateral research expenditure	$m 2002–03 actual	$m 2003–04 budget	$m 2004–05 budget	$m 2005–06 indicative
Active projects	2.40	2.52	1.59	0.7
Committed funds for new projects			0.85	0.9
Projects under design			0.07	0.2
Available for new projects			0.00	0.3–0.5
Total	2.40	2.52	2.50	2.2–2.4

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. Broad-scale land and water resource management work emphasises technical and policy research on water management. The program, which has a geographic emphasis in north and central India, aims to underpin continued high production in favoured lands as well as sustainable production in more marginal lands. During 2004–05 there will be an increased focus on developing projects that target poor marginalised farmers in particular states within rain-fed, semi-arid areas of north and central India, through demand-led projects that have linkages to enable upscaling of successful research outputs. Projects will aim for increased impacts both in the field to improve livelihoods and reduce risk, and at the national level to support policymakers.

Key performance indicators

- New arrangements for ACIAR project management and execution in India implemented, including greater involvement of NGOs and independent research institutes
- Half of the new projects emphasise the rain-fed tropics and subtropics
- Increased emphasis on demand-led project identification in rain-fed semi-arid tropics, and all new projects have well-defined adoption pathways
- Farmers in Gujarat purchasing protected nutrient livestock feeds produced on a commercial basis
- Improved institutional policies arising from ACIAR project research, promoting more equitable and efficient water use
- Novel seeding machine to handle heavy rice residues tested widely in Punjab State.

Position

In September 2003, the Government of India (GoI) advised the Australian Government that it had developed new policy guidelines for bilateral donors. In the future it is expected that ACIAR collaboration with the Indian Council of Agricultural Research (ICAR) and the Council of Scientific and Industrial Research (CSIR) will be jointly funded and focused on high priority issues of mutual interest. The GoI is encouraging donors to work with independent research organisations (IROs) and NGOs. A number of these organisations have successfully collaborated with ACIAR in India over the last 8 years, and this option will be further developed and utilised during 2004–05. Collaboration with partners such as State Agricultural Universities and Government research institutes through projects that are led by Indian IROs and NGOs will be possible. Our projects will have an increased emphasis on achieving practical farmerlevel and policy impacts, particularly in poorer regions of India.

India was one of the first countries to become involved in collaborative projects commissioned by ACIAR. Early projects on wheat rust control by breeding and introduction of short-season pigeonpea

varieties into marginal farmlands have helped improve the welfare of the extreme poor. Improved sorghum varieties have also been introduced in these marginal areas. 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 adoption of minimal tillage approaches in rice–wheat farming systems, with significant benefits for moisture conservation and weed management in cropping.

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, the National Dairy Development Board, independent research organisations and technical NGOs have facilitated technology development and the delivery of benefits. ACIAR engages mainly with centres in north and central India, where research projects are presently underway to manage scarce water and nutrient resources more efficiently, improve yield and quality of grains and legumes, and diversify production and raise farm incomes.

One major IARC, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), is headquartered in Hyderabad, India. 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 program on policy issues delivered through partnerships with government, research institutes and NGOs. ACIAR supports projects with these IARCs.

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. 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 will continue 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.

Key program managers for India

Dr Ray Trewin, Agricultural Development Policy
Dr John Copland, Animal Sciences 1
Dr Colin Piggin, Crop Improvement and Management
Dr Ian Willett, Land and Water Resources
Dr Christian Roth, Soil Management and Crop Nutrition

Pakistan

Population	144.9 million
GNI per capita	AUD 755

Pakistan: Bilateral research expenditure	$m 2002–03 actual	$m 2003–04 budget	$m 2004–05 budget	$m 2005–06 indicative
Active projects	0.21	0.51	0.32	0.2
Committed funds for new projects			0.18	0.2
Projects under design				0.0
Available for new projects				0.0–0.2
Total	0.21	0.51	0.50	0.4–0.6

Strategy

ACIAR's Pakistan strategy is to maintain a small program of bilateral and IARC projects focusing on major natural resource problems accompanying irrigated and dryland cereal cropping, such as efficient water use, salinity and drainage.

Key performance indicator

- Initiation of a project to extend positive results obtained on use of permanent raised beds for irrigated maize–wheat cropping.

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. Since late 2001, security considerations have hindered the progression of some projects under development in Pakistan.

Indicative priorities

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

Future collaboration will focus on land and water resources, including crop water use and salinity, dryland farming systems, wheat and food legume production. However, the progression of further research cooperation in the short term is dependent on security considerations.

Key program managers for Pakistan

Dr Ian Willett, Land and Water Resources
Dr Christian Roth, Soil Management and Crop Nutrition

Bangladesh

Population 135.7 million
GNI per capita AUD 663

Bangladesh: Bilateral research expenditure	$m 2002–03 actual	$m 2003–04 budget	$m 2004–05 budget	$m 2005–06 indicative
Active projects	0.37	0.29	0.24	0.3
Committed funds for new projects			0.00	0.0
Projects under design			0.00	0.0
Available for new projects			0.00	0.0
Total	0.37	0.29	0.24	0.3

Strategy

ACIAR's strategy in Bangladesh is to focus on constraints to the production and postharvest handling of broadacre grain crops, through projects led by IARCs and linking to their existing programs.

Key performance indicators

- Outputs from arsenic project adopted by Bangladesh government and other agencies
- Training of farmers in diagnosis and management of Botrytis grey mould and pod borer of chickpea.

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 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. A socioeconomic project has also been undertaken on the rice–shrimp production system. 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, which is funded by AusAID and several international donors.

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, with some work on land and water resources. In the medium term, ACIAR will only consider projects in the area of crop management and sustainable production issues that also form part of programs of IARCs.

Key program managers for Bangladesh

Dr Colin Piggin, Crop Improvement and Management
Dr Christian Roth, Soil Management and Crop Nutrition

Other South Asian Countries

Population 72 million
GNI per capita AUD 680

Other South Asia: Bilateral research expenditure	$m 2002–03 actual	$m 2003–04 budget	$m 2004–05 budget	$m 2005–06 indicative
Active projects	0.62	0.50	0.24	0.0
Committed funds for new projects			0.03	0.0
Projects under design				0.0
Available for new projects				0.0–0.2
Total	0.62	0.50	0.27	0.0–0.2

Position

Currently ACIAR supports one active project in Nepal, two active projects in Sri Lanka and one active bilateral project in Bhutan. One multilateral project commenced in 2002–03 in Afghanistan2. Due to funding constraints, ACIAR is not considering proposals for new projects in Nepal or Sri Lanka in 2004–05. In Bhutan, only proposals for new projects that are initiated and endorsed at an early stage by the Bhutan Government will be considered in 2004– 05. ACIAR has no formal program of consultations on priorities with these countries. However, 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

- Documentation of a significant increase in aquaculture production from seasonal tanks in five districts (Sri Lanka)
- Provision of new lentil cultivars to farmers (Nepal).

Key program managers

Dr Colin Piggin, Crop Improvement and Management
Dr Greg Johnson, Postharvest Technology
Dr Christian Roth, Soil Management and Crop Nutrition

Nepal

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 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). Multilateral involvement has taken place earlier via the International Centre for Integrated Mountain Development (ICIMOD), based in Kathmandu.

Sri Lanka

Sri Lanka was an original partner of ACIAR's; the high quality of training of many Sri Lankan agricultural scientists and their excellent English 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. Several of the outputs are being used in new 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 waterweed. On occasions, ACIAR supports Sri Lankan scientists as specialist advisers to assist in projects in the region.

Bhutan

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

Afghanistan

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 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. This objective is being achieved principally through provision of seed of suitable cultivars via import, establishment of on-farm participatory testing of imported germplasm nurseries for the ongoing identification of better adapted improved cultivars, and local multiplication and distribution of improved cultivars. Particular attention will be paid to yellow rust resistance in wheat and to promoting improved crop management along with improved cultivars. The capacity of local NGOs, state scientists and farmers will benefit. The projects are co-funded by AusAID and ACIAR, managed by ACIAR and executed by CIMMYT.

Country Manager

Dr Kuhu Chatterjee, ACIAR Country Manager South Asia
Dr Tony Fischer, Program Adviser, South Asia

Active projects

as at 1 December 2004

India: bilateral

ADP/2000/004: International food safety regulation and processed food exports from developing countries: a comparative study of India and Thailand 23

ADP/2001/014: Improving water resource management in India's agriculture: search for effective institutional arrangements and policy frameworks 25

AS1/1997/058: Increasing the productivity of cattle in India and Australia with rumen fungal treatments 27

AS1/1997/115: Increasing efficiency and productivity of ruminants in India and Australia by the use of protected nutrient technology 29

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AS2/2001/029: Development of a knowledge system for the selection of forages for farming systems in the tropics (India; Pakistan) 34

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CIM/2002/030: Improving subtropical citrus production in Sikkim and Australia 41

FIS/2002/001: Developing aquaculture in degraded inland areas in India and Australia 43

FST/1995/106: Improving and maintaining productivity of eucalypt plantations in India and Australia 44

FST/1998/096: Domestication of Australian trees for reforestation and agroforestry systems in developing countries 46

PHT/2001/026: Drying systems to improve grain quality in north-east India 47

SMCN/2000/089: Permanent beds for irrigated rice–wheat and alternative cropping systems in north-west India and south-east Australia 49

SMCN/2002/032: Integrated manure nutrient management in soybean/wheat cropping systems on vertisols in Madhya Pradesh and Queensland 51

India: multilateral

AS2/1999/062: Improving the quality of pearl millet residues for livestock 52

LWR/2003/026: Water allocation in the Krishna River Basin to improve water productivity and agriculture 53

Pakistan: bilateral

AS2/2001/029: Development of a knowledge system for the selection of forages for farming systems in the tropics 54

CP/1995/003: Control of Gemini virus diseases of cotton and tomato in Pakistan and Australia 56

FST/1998/096: Domestication of Australian trees for reforestation and agroforestry systems in developing countries 58

LWR/2000/013: Sustainable agriculture in saline environments through serial biological concentration 59

SMCN/2002/034: Refinement and adoption of permanent raised bed technology for the irrigated maize–wheat cropping system in Pakistan 60

Bangladesh: bilateral

CIM/2001/039: Integrated management of Botrytis Grey Mould of chickpea in Bangladesh and Australia 61

LWR/1998/003: Arsenic transfer in water–soil–crop environments of Bangladesh and Australia 63

Bangladesh: multilateral

CIM/2004/003: Plant health management for faba bean, chickpea and lentils 65

Other South Asian countries: bilateral

CIM/1999/064: Lentil and Lathyrus in the cropping systems of Nepal: improving crop establishment and yield of relay and post-sown pulses in the Terai and mid-hills 66

CP/1997/101: A survey of fruit flies in Bhutan and a field control program for *Bactrocera minax* (Enderlein) (the Chinese citrus fly) 68

FIS/2001/030: Management strategies for enhanced fisheries production in Sri Lankan and Australian lakes and reservoirs – extension project 69

FST/1998/096: Domestication of Australian trees for reforestation and agroforestry systems in developing countries (India, Pakistan, Sri Lanka) 71

PHT/1997/094: Management of postharvest diseases of subtropical and tropical fruit using their natural resistance mechanisms (Sri Lanka) 72

Other South Asian countries: multilateral

SMCN/2004/002: Wheat and maize productivity improvement in Afghanistan 74

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 Email: prema-chandra.athukorala@anu.edu.au
Collaborating Institutions:	Research Information Systems for the Non-aligned and Other Developing Countries, India Thammasat University, Thailand International Food Policy Research Institute, USA University of Melbourne, Australia
Project Budget:	$546,150
Project Duration:	01/01/2002 to 31/12/2004
ACIAR Research Program Manager:	Dr Ray Trewin

Project background and objectives

This study is examining the impact of sanitary and phytosanitary measures on the ability of (agricultural exporting) developing countries to achieve the full benefits of trade liberalisation. Particular emphasis is placed on the role of the Sanitary and Phytosanitary (SPS) Agreement and the related WTO dispute settlement procedure in cushioning exporters of agricultural and food products against trade-retarding effects of SPS measures, with emphasis on the related compliance issues and institutional constraints. The project is examining the trade impact of SPS standards, to distinguish between the degree to which that impact relates to the nature of SPS measures themselves versus the limited capacity of the governments and exporters in developing countries to comply with such measures. The study will yield important policy recommendations for further improvement of the current WTO procedure for SPS dispute settlement, and for enhancing technical, scientific and institutional capacity in India and Thailand. The issues also have particular relevance to Australia, a key member of the Cairns Group, in bridging the gap between agricultural exporting developing countries and developed countries in international trade talks.

Project progress

Year 2 (01/01/2003-31/12/2003)

The main tasks accomplished during the first year of the implementation period included:

- the literature survey
- analysis of trends and patterns of processed food exports from developing countries and the WTO mechanism for monitoring food safety standards
- the institutional mechanisms and procedures for meeting food safety standards in India and Thailand
- case studies of the selected food industries in the two countries, and finalising the questionnaire for the firm-level survey.

The prime focus of the Indian and Thai research teams was on conducting the firm-level survey. The Indian team has completed surveying 23 firms. These include firms in the following industries: shrimp (12) mango pulp (four), egg powder (three) and mushroom (three) industries in the states of Kerala, Tamilnadu, Andra Pradesh Chandigar and Maharashtra. The Thai team has surveyed 24 Shrimp exporting firms and 3 caned tuna exporting firms.

The Australian team was mainly involved in finalising the two background chapters on the relative export performance of India and Thailand in world food trade, and the experience of developing countries in participating in WTO mechanism for monitoring international food safety, in addition to monitoring and coordinating field research in the two countries.

The Indian collaborating institution, Research Information Systems (RIS), held an in-country workshop in March 2004, to discuss the preliminary findings of the field survey and to provide inputs into the on-going policy debate in India on international food safety standards and the related WTO procedures. About 40 participants, representing food processing industry and relevant government organizations in India attended the workshop.

The second interim workshop was held in Bangkok during March 2004. In addition to the members of the research tem and ACIAR representatives, 23 government officials and private sector representatives in Thailand and four observers involved in an ongoing ACIAR project in Vietnam attended the public sessions on the first day of the workshop. The conference presentations included two country papers based on the preliminary results of the firm-level surveys in India and in Thailand, an overview paper on lessons of experience and new issues relating to international food safety standards and processed food exports from developing countries.

In addition, two invited papers were presented, one on the implications of Avian Influenza—a major new development that affected many Asian countries including Thailand in recent months—for world food trade and WTO issues, and the other on methodological issues involved in firm-level analysis of trade implications of food safety standards.

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 Email: l.crase@aw.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 30/06/2005
ACIAR Research Program Manager:	Dr Ray Trewin

Project background and objectives

In India expansion and improvement of irrigation has been a key feature of the country's strategy to assist those dependent on agriculture in areas of uncertain rainfall. However, water resource management is in crisis and constraining agricultural growth. The major problem is not technical or economic but institutional - there is little understanding about socially acceptable institutional arrangements and policies that will promote sustainable irrigation practices. This project is designed to specifically address this information void, identifying and evaluating the key features of institutions and policies for promoting efficient and sustainable management of water resources in India. Given the highly significant nature of the research problem, the findings could make large economic, social and environmental impacts.

Project progress

Year 2 (01/07/2003-30/06/2004)

The process of signing for the project was completed in late January, 2003 and work for the project commenced in earnest in February 2003. In the first 18 months of operating two main activities were achieved:

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

This has allowed the project to focus on five main areas:

1. the refinements and extension of the theoretical elements of the institutional framework following scrutiny by participants at the initial international workshop
2. selection and case analysis of 16 institutional scenarios in India covering ground water, check dams, co-operatives and water user associations
3. the development of statistically robust items for measuring the perceptions of irrigators as they pertain to the main elements of water institutions
4. development of a survey instrument for making comparisons between water institutions in India and Australia
5. undertaking field work in India in January 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.

The initial institutional review highlighted five main criteria that warranted consideration. Namely:

- clear institutional objectives
- connectedness between formal and informal institutions
- adaptability
- appropriateness of scale
- compliance capacity.

Hitherto, calibration of institutional criteria has relied largely on a range of heuristics. One of the significant contributions of this project is the attempt to develop and apply empirical estimation techniques.

To ensure that empirical measures are meaningful in the differing contexts of irrigation in India, an extensive situational analysis was initially undertaken in the second reporting period. Examining the performance of water institutions has historically proven problematic in the absence of a metric that can be applied in differing contexts. During the second reporting period a range of items were trialled to test the reliability of survey items capable of accurately capturing irrigator's perceptions of institutional performance. Developed initially within Australia, these items are of a sufficiently broad level to allow comparisons across different settings. For example, four items now consistently capture irrigator's underlying perceptions about the clarity of the rules under which the institution operates. Similarly, four items consistently measure the irrigators' views on the adaptability of rules. Combined with on-the-ground data these items (20 in total) are to be incorporated in modelling work scheduled for the third reporting period.

AS1/1997/058: 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 2820 Email: chris.mcsweeney@csiro.au
Collaborating Institutions:	National Institute of Animal Nutrition and Physiology, India
Project Budget:	$682,519
Project Duration:	01/01/2003 to 31/12/2005
ACIAR Research Program Manager:	Dr John Copland

Project background and objectives

Ruminants on diets of low quality roughage fail to thrive. This project aims to improve the productivity of such ruminants by adding fungal inoculants and a selective supplement to their diet, thus enhancing fibre degradation and increasing the digestive efficiency of the rumen. Development of the technology to enhance fibre digestion and fermentation using anaerobic fungi should result in productivity gains of 5-15% in sheep. The project is focusing on cattle, particularly dairy cattle, where inputs (feed) and outputs (milk) are monitored closely. The project scientists are working to identify superior fungi that persist in the rumen of cattle fed diets with appropriate fibre content, and develop a prototype method to produce large volumes of inoculum of these fungi. They are testing and confirming that the fungus-specific feed additives are effective in cattle, and determine how to supply cost - effective inoculum and the food additive to the dairy cattle/buffalo industry in India.

Project progress

Year 1 (01/01/2003-31/12/2003)

A nutrition trial was conducted in cattle to evaluate the impact of a fungus-specific nutrient (mercaptopropionic acid, MPA) and sulphate on rumen function and digestion. The addition of the sulfur supplements resulted in increased feed intake and flow of microbial protein to the small intestines when the animals were fed a poor quality roughage low in sulfur (S) and nitrogen (N). Both supplements improved rumen function by stimulating the microbial population to incorporate more ammonia N for protein synthesis. The study also demonstrated that the animals would benefit from additional supplemental urea for complete utilisation of the S based supplements. Molecular ecology methods were developed to quantify the changes in fibre degrading microbial populations to the S based supplements. MPA appeared to increase fungal populations while sulfate supplementation increased the Fibrobacter population as a proportion of the total bacterial population.

A complimentary animal trial is currently underway in India using the same treatments on larger groups of animals to provide more accurate production response data. The cattle nutrition trial has demonstrated that both sulfur supplements are stimulating the supply of microbial protein to the animal and improving nitrogen balance. MPA also appears to be stimulating fungi as predicted. Increases in fibre degrading micro-organisms in the rumen may be driving improvements in digestible dry matter intake. Future animal trials will focus on which S supplements give the greatest and most consistent production response. 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.

In addition to sulfur supplements it is planned to dose animals with highly cellulolytic fungi which may also enhance fibre digestion and improve nutrient supply to the animal. Significant progress has been made in isolating superior fibre-degrading strains of anaerobic fungi in India and Australia that have the potential to persist in the rumen of cattle and buffaloes. In Australia a search for highly fibrolytic fungi has resulted in the isolation of several organisms, which appear to be superior to those in

culture collections in North America and the UK. The best fibre degrading fungi adhere strongly to fibre and grow rapidly while digesting greater than 50 per cent of the fibre fraction in poor quality Rhodes grass and Spear grass. These fungi are a diverse group and belong to the genera *Orpinomyces*, *Piromyces* and *Neocallimastix*. An elite strain from each of these three groups is being prepared for inoculation into cattle so that their impact on feed intake and production responses in conjunction with the sulfur supplements can be determined.

AS1/1997/115: 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: 0419 194 986 Email: sureshg@vetsci.usyd.edu.au
Collaborating Institutions:	National Dairy Development Board, India
Project Budget:	$556,514
Project Duration:	01/01/2000 to 30/06/2004 (Project extended from 01/01/2003 to 30/06/2004)
ACIAR Research Program Manager:	Dr John Copland

Project background and objectives

Poor nutrition limits ruminant production in many regions of the Indian subcontinent and Australia. Productivity could be lifted if more protein and fat could be made available through feed supplements such as oilseed meals and residues of coconut and oil palm. CSIRO has developed a formaldehyde treatment to protect lipid and protein feedstuffs from breakdown during the digestive processes in the rumen, leading to more efficient absorption lower in the gut. This project builds on earlier ACIAR-funded research, focusing on developing this technology for India to produce feed supplements that contain optimal by-pass proteins and fats. The scientists will also extend the technology to alternative feed supplements in Australia.

Project progress

Year 4 (01/01/2003-31/12/2003)

Maximise production, monitor maintenance and safety aspects of the by-pass protein unit at the cattle feed plant at Itola, Gujarat, India
Production of by-pass protein at the Itola plant in India was maximised, by installing a rapid device to bag feed after a few hours of production. Dust bags and safety windows were installed to ensure occupational health and safety procedures are followed. Production per month in February 2004 approached 300 MT of pellets containing the by-pass protein. Quality control of feed supplements was monitored to ensure that by-pass protection specifications are met. All supplements manufactured were within specification with protein by-pass content of 70-75 per cent.

Transfer the by-pass protein technology to village farmers in Gujarat State
A workshop on feeding strategies for the efficient utilisation of existing feed resources to reduce the cost of milk production, which included protected by-pass proteins, was conducted at the National Dairy Development Board in November 2003 for researchers, government and industry representatives, small and large farmers to identify the best combination of resources to boost milk production in India. The workshop published guidelines to achieve this, which is in the process of being implemented in conjunction with NDDB/researchers/industry and village farmers.

Economic evaluation of the feeding trials in the Baroda district
Socio-economic analysis on the use of by-pass protein at the village level was undertaken, with a preliminary analysis indicating the benefits and economic impacts at the village level were greatest for farmers milking buffaloes followed by local cows and crossbred cows, with a net additional income of Rs 12.41, Rs 9.26 and Rs 7.28 respectively per animal per day.

Undertake regional feeding trials with by-pass protein supplements
Regional trials were conducted using by-pass protein supplements produced at the Itola plant in the East, North and Southern regions of India. Increases in milk production (1-2 L per animal per day) were observed in the North (Karnal) and East (Orissa), but a smaller response was obtained in the South (Kerala) where feed quality and quantity was not limited during the trial.

AS1/2001/005: 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 9545 2365 Email: catherine.money@.csiro.au
Collaborating Institutions:	Central Leather Research Institute, India
Project Budget:	$766,089
Project Duration:	01/07/2002 to 30/06/2005
ACIAR Research Program Manager:	Dr John Copland

Project background and objectives

Australia and India share a common interest in processing of hides and skins with the industry of major importance to both countries. Tannery wastes, as measured by Total Dissolved Solids (TDS), have been a significant cause of pollution in the past and remain so today. Australian regulators and tanners have acknowledged salinity reduction as a priority research area, and there have been tannery closures in both countries due to increasing public demand for pollution control. The prescribed discharge levels for most of the pollutants are being met except for TDS. Project scientists are evaluating and applying systems to reduce salt use in hide and skin preservation and processing. The overall project aim is prevention rather than treatment and should result in significant reduction of TDS in tannery effluent.

Project progress

Year 2 (01/07/2003-30/06/2004)

Hide and skin preservation
It now seems unlikely that drying or dry-salting will be adopted for skin preservation. Low salt preservation and chilling will both greatly reduce salt use and are far more likely to be implemented.

Low salt preservation
Rather than drying skins in India, it is more feasible for the first handlers of the skins to salt unopened skins as usual with about 20per cent salt by weight. Collection centres, often already controlled or influenced by tanners, will apply additives as necessary to preserve the skins for 7 to 21 days as required. This will reduce salt use 3 to 4-fold, from 60-80 per cent, and there will be few salt crystals on the skins and little solid salt waste. Evaporation of soak liquors will be required, as is the case at present. As waste salt will be significantly reduced, all the evaporated salt should be able to be re-used or used as a fertiliser for coconut palms.

The Indian Environmental Charter excludes the use of boron compounds. The concentration of such compounds in Indian tanning centres could lead to build-up of damaging levels in soils. Trials have shown the most suitable additives to be magnesium oxide or naphthalene.

A large Tamil Nadu tannery is very supportive of the project and is trialling low salt preservation of skins. They have more than 10 collection centres and the new system is initially being trialled in Delhi.

In Australia, a skin merchant and a major woolskin tanner are collaborating with CSIRO in commercial trials of low salt preservation. Several additives have been compared, including boron compounds which are already widely used in Australia. Low salt preservation could reduce salt use seven-fold.

Chilling of hides and skins to replace salting
Chilling now appears to be viable for some hides and skins in parts of India. CLRI have done some trials and cost calculations and is purchasing a mobile chilling unit for industry trials and demonstrations. This will initially be used for chilling hides in Kerala and transportation to KKSK, a large hide tannery in Erode. When trials have been completed, KKSK plans to have chillers in both

Kerala and Erode and to use insulated trucks for transport. KKSK will first prove the technology and then purchase chillers. It is possible that 15 Erode Tanners could combine in a chilling enterprise.

Socio-economic issues
The major socio-economic issues for the Project were originally considered to relate to adoption of air drying of skins. However, the low salt preservation will be far easier to implement. The technology transfer and training will be easier than anticipated because the tanners will be the champions of the new technology and tannery technicians will be involved in the training of their skin suppliers. The collaborating tanners say that once the technology is proven to them, they will adopt the new systems, champion them, and the rest of the industry will follow.

An Industry Workshop on Proposed Preservation Changes was held in April to discuss implications for market practices and socio-economic issues. There were 28 participants including tanners and hide and skin dealers. Participants agreed that there must be change and gave positive feedback for the project. It was agreed by the dealers that the proposed low-salt preservation would entail little change for first handlers of skins and the main issue was who would pay if costs increase. One possibility raised was that to bring about change, the tanner could pay more for skins with less salt and good preservation and less for skins with excess salt. The costs associated with chilling were discussed and it was generally accepted that those who gain from the development should bear the cost. Chilling will first be tried with hides slaughtered in Kerala and tanned in Erode but it is a possibility for other centres from Bangalore to Ranipet. Raw skin dealers said they could not invest in a chiller but tanners may do this and it is a possibility that the Government may provide loans which industry would repay. Costs and benefits first need to be determined.

Direct chrome liquor recycling
Initial commercial trials at a major tannery have been successful.

Pickle Recycle
A Dindigul tannery which usually discharges pickle liquor after each use has successfully done trials for eight uses and is advocating the system to other tanners. Equipment to facilitate recycling is being installed. Recycling in Australia has been successfully extended and has been monitored for 200 uses.

AS1/2002/038: 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
	Email: swalkden@metz.une.edu.au
Collaborating Institutions:	National Chemical Laboratory, Division of Biochemical Sciences, India
	Nimbkar Agricultural Research Institute, Animal Husbandry Division, India
	University of Melbourne, Centre for Animal Biotechnology, Australia
Project Budget:	$397,727
Project Duration:	01/01/2003 to 31/12/2005
ACIAR Research Program Manager:	Dr John Copland

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 (FecB) seems to have originated in the Garole sheep from the Sundabans in eastern India. The Garole also has considerable resistance to *Haemonchus contortus*, the predominant parasite of sheep in India and Australia. This project will produce and test appropriate genotypes and develop extension models to assist the poorer shepherd communities of Maharashstra.

Project progress

Year 1 (01/01/2003-31/12/2003)

Production of appropriate genotypes for testing in shepherds' flocks (India)
This work is centred at the Nimbkar Agricultural Research Institute (NARI) where over 700 breeding ewes of various breeds and crosses are maintained. The breeding work at NARI has three broad purposes, namely:

- the development of a fecund Deccani sheep by introgression of the FecB gene
- the development of composite meat breed
- the maintenance of sufficient Deccani purebreds to act as a benchmark for analysis of performance of the improved genotypes.

All breeding is done by artificial insemination (AI) using fresh semen to facilitate accurate pedigrees. Genotyping of lambs for the FecB gene occurs early in life using the PCR-RLFP test at the National Chemical Laboratory (NCL), Pune. By July-August 2003 there were 223 mature crossbred ewes carrying the FecB gene at NARI of which 197 were inseminated. This is slightly ahead of target. A total of 647 ewes were inseminated at this mating.

Testing of improved genotypes in shepherds' flocks and development of appropriate management technologies
A total of 78 ewes (38 FecBB+, 40 FecB++) were distributed amongst nine local shepherd flocks during 2003, exceeding the target for 2003. These ewes produced a total of 98 live lambs with 83 surviving lambs. Mortality did increase with litter size. In addition total of 10 FecBB+ (heterozygote) rams were introduced to 12 local flocks for 35-74 days producing 116 conceptions and 59 lambs. Of these lambs 29 have been shown to carry the FecB gene. Management practices of the participating shepherds are being closely monitored, particularly in relation to managing multiple births.

Regulation of expression of FecB in Indian and Australian sheep breeds (India and Australia)
In India, analysis of data at NARI revealed that one copy of FecB increased ovulation rate and litter size in multiparous ewes. The results were similar when records of ewes of different genetic backgrounds were added to the analysis, revealing that the FecB gene appears to act independently of the overall genetic background of carrier animals. The effect of the first copy of the FecB gene on ovulation rate in this study was lower than the 1.65 ova per copy reported for the Booroola Merino. However, the increase in litter size with one copy of the gene in this study is similar to that reported in the literature for the Booroola Merino.

An experiment examining the effect of nutrition on expression of the FecB trait in Garole ewes was conducted. The data still requires complete analysis but pre-mating level of feeding did not appear to have had a major effect on body weight or litter size possibly due to feed substitution effects.

In Australia, DNA samples have been collected from 428 Merino ewes on a commercial Merino property in Southern NSW into which the FecB gene had been introduced in the 1980s. Of these, 329 ewes have now been genotyped. When genotyping is complete the data will be analysed to determine the expression of the FecB trait in these genotypes and any associations with production variables. This represents the first large-scale genotyping of sheep for the FecB trait in Australia, using the PCR-RLFP test. The test is now established at UNE where most of this genotyping has occurred.

Development of extension and genetic models for the dissemination of proven genotypes (India and Australia)
In Australia and India a PhD student is nearing the end of the second year of study at UNE under an ACIAR John Allwright Fellow. Good progress has been made on developing economic values for sheep production traits in Maharashtran sheep production systems and modelling the impact of introgressing the FecB gene in these systems. This work will form an important part of her doctorial thesis, as will an analysis of methods of introgressing the gene into a large sheep population.

AS2/2001/029: Development of a knowledge system for the selection of forages for farming systems in the tropics

Overseas Collaborating Countries:	China, India, Indonesia, Pakistan, Philippines, South Africa, Vietnam
Commissioned Organisation:	CSIRO Sustainable Ecosystems, Australia
Project Leader:	Dr Bruce Pengelly
	Phone: 07 3214 2348
	Email: Bruce.Pengelly@csiro.au
Collaborating Institutions:	International Center for Tropical Agriculture, Colombia
	International Livestock Research Institute, Ethiopia
	Queensland Department of Primary Industries and Fisheries, Australia
	University of Queensland, Australia
Project Budget:	$837,717
Project Duration:	01/07/2002 to 30/06/2005
ACIAR Research Program Manager:	Dr Bill Winter

Project background and objectives

In the developing world sown tropical forages can provide part of the feed base to support the expanding market for livestock products. Forages can improve feed quality and quantity in a range of farming systems. However, adoption has been limited for a number of reasons, including poor access to appropriate information. Much of the important information is fragmented, unpublished or published in media of limited circulation. This project intends to synthesise and interpret what represents much of the accumulated information on species adaptation, use and management over the last 50 years from across the tropical world. It will be combined into one knowledge system (SoFT – Selection of Forages for the Tropics). The completed product will be a computer-based system that can be used to select 'elite' forage accessions tailored to specific farming systems and environments.

Project progress

Year 2 (01/07/2003-30/06/2004)

The development of a computer based selection tool and database is progressing. with the collaboration of a large number of forage experts from across the tropics and aims to deliver an expert system that will provide information on the management, use and variation between cultivars and elite accessions for over 120 major forage species for smallholder and large scale agricultural systems.

Develop a knowledge system for the identification of forages suitable for specified niches within smallholder farming systems
Nineteen attributes have been selected for use in the SoFT with between two and eight states in each attribute. Selection criteria available in the SoFT database for selecting the most suitable forages for environments and uses

Climate/farming system attributes	*Soil environment attributes*	*Plant attributes*
Latitude x altitude	Soil pH	Plant family (legume or grass)
Rainfall (average annual)	Level of available soil Al/Mn	Life cycle
Length of dry season	Level of soil salinity	Growth form
Inundation	Soil drainage	Stem habit
Intended forage use	Soil texture	Cool season growth
Grazing pressure	Soil fertility	Frost tolerance (foliage damage)
Shade environment		

SoFT selections are dependent upon the coding for each species in each attribute. This coding has been carried out by the Australian team members using their own experience in addition to the information from the workshops and literature reviews. The selection tool component of the database has been undergoing testing to ensure that selection outcomes are appropriate and that no obvious species are omitted

Each fact sheet in the database will have about 5 photos. So far over 1,000 high quality photos of forages have been sourced from forage scientists in Australia and overseas and have been placed in a database for filing and access. Photo subjects include juveniles, plants and forages being used.

Three workshops were held during the year at the of University of Hohenheim at Stuttgart Germany, in Cali, Colombia and in Hanoi, Vietnam, attended by more than 40 forage scientists. The workshop in Hanoi took place in conjunction with the annual meeting of the Forages for Smallholder Projects. Literature searches have continued and over 6,000 references have been assembled for the database.

Fact sheets have been written for about 70 of the most important fact sheets and a further 50 are expected to be completed before the database goes to press in March next year. These fact sheets are being written with a specific format and are of various lengths, depending primarily on the importance of the species.

Promote the system within the 'communities' who are using tropical forages
More than 70 agronomists have now attended project workshops across Asia, Africa, Central and South America, and Australia Negotiations are underway with FAO to have the database linked to their website and for FAO to be a distributor of the CD version. The project leader also plans to visit CABI in late 2004 to discuss the role of the database within their compendium system. The web version of the project will be housed on the CIAT website, with links from the CSIRO Sustainable Ecosystems website

Develop a strategy for maintenance and updating the knowledge system
Discussions with FAO and the project team about options for maintenance of the Database are continuing and it is proposed that FAO will take a leading role in partnership with CIAT to maintain the database. This arrangement will be crucial in ensuring that CIAT and others are equipped to deliver upgrades of the SoFT database.

CIM/1996/007: Traits for yield improvement of chickpea in drought-prone environments of India and Australia

Overseas Collaborating Countries:	India
Commissioned Organisation:	University of Western Australia (Centre for Legumes in Mediterranean Agriculture), Australia
Project Leader:	Dr Neil Turner Phone: 08 9333 6612 Email: turner@ccmar.csiro.au
Collaborating Institutions:	CCS Haryana Agricultural University, India Indian Agricultural Research Institute, India Indian Council of Agricultural Research, India Indian Institute of Pulses Research, India International Crops Research Institute for the Semi-Arid Tropics, India JNKVV Agricultural University, India Agriculture Victoria, Australia CSIRO Plant Industry, Australia NSW Agriculture, Australia Queensland Department of Primary Industries and Fisheries, Australia South Australian Research and Development Institute, Australia
Project Budget:	$735,679
Project Duration:	01/07/1998 to 30/06/2005 (Project extended from 01/07/2001 to 30/06/2005)
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

Chickpea is an important protein-rich crop in India, West Asia and North Africa. In Australia it is useful as a high-value export crop, a source of nitrogen and a disease break when planted prior to cereal or oilseed crops. But when grown in drought-prone areas, its yields are only 0.5-0.8 tonnes per ha, and this project aims to lift those yields. Scientists will define the limitations to yield under dryland conditions then breed lines with physiological characteristics most able to withstand drought. They will develop breeding populations to test the best methods for screening superior characteristics and determine whether they can use molecular technologies for improving the efficiency of breeding for drought resistance.

Project progress

Year 6 (01/07/2003-30/06/2004)

In Australia, recombinant inbred lines have been developed for three traits considered to give improved chickpea yields and quality in drought-prone environments:

- high osmotic adjustment
- large assimilate remobilisation to the grain
- high sucrose synthase activity in the seed.

In 2003 the lines differing in assimilate transfer were progressed in glasshouses. Twenty-five families differing in osmotic adjustment and sucrose synthase were sown in the field at the Dryland Research Institute at Merredin in Western Australia. These were covered with a rainout shelter during pod filling for evaluation of the degree of variation in osmotic adjustment and sucrose synthase activity. Preliminary evaluation will be done on the effects of these traits on seed yield and seed size. The

results from 2003 showed that there was considerable variation in osmotic adjustment among these lines. Three lines with a high degree of osmotic adjustment and three with a low degree of osmotic adjustment have been selected for measurement and evaluation of yields under water-limited conditions in 2004-05 in Australia and India. The lines also varied in their seed size, and lines with similar phenology.

In 2004, seeds of the lines differing in osmotic adjustment that were to be grown in Australia were also transferred to India for multiplication and distribution to the Indian partners. It was agreed at the annual planning meeting held at the Indian Institute of Pulses Research that the lines will be grown under rainfed conditions in Gulbarga, Sehore, Jaipur and Kanpur in 2004-05. The influence of osmotic adjustment on yield under rainfed conditions in India will be evaluated. The degree of osmotic adjustment will also be evaluated at the site at Kanpur.

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:	Department of Agriculture, Western Australia, Australia
Project Leader:	Dr Tim Setter Phone: 08 9368 3289 Fax: 08 9474 2840 Email: tsetter@agric.wa.gov.au
Collaborating Institutions:	Central Soil Salinity Research Institute, India Directorate of Wheat Research, India ND University of Agricultural Technology, India Department of Primary Industries, Victoria, Australia University of Western Australia, Australia
Project Budget:	$826,426
Project Duration:	01/01/2001 to 30/06/2005 (Project extended from 01/01/2005 to 30/06/2005)
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

It is difficult to grow wheat in waterlogged soils, and the physical works needed to alleviate waterlogging are often too costly for resource-poor farmers to undertake. Therefore the development of wheat varieties that tolerate waterlogging is a sustainable solution for improving their crop productivity. A multidisciplinary group of scientists are tackling the problems involved:

- characterising waterlogging environments
- producing techniques to screen for key aspects of waterlogging tolerance in wheat and barley
- developing wheat and barley germplasm to supply breeders who are developing more waterlogging tolerant cultivars.

Training will be a substantial component of the program.

Project progress

Year 3 (01/01/2003-31/12/2003)

Good progress has been made in all objectives during 2003, with key information coming from environmental characterisation of waterlogging (WL) prone areas, physiology, germplasm evaluation and development. Further environmental characterisation has:

- provided a better understanding of the nature of constraints that wheat crops experience during WL and also the extent and severity of the problem
- led to identification of two distinct WL environments based on soil parameters and their interaction with genotypes in Australia and India.

Knowledge on the WL environments will be useful in improving the already developed protocols for controlled WL screening experiments in Australia and India. These protocols differ in separate locations due to major discrepancies in environmental factors including temperature, soil constraints and its biological activity, organic matter and nutrition.

Field evaluations in Australia and India integrated with laboratory and glasshouse based studies under controlled conditions revealed:

- identification of genotypes with tolerance to WL to be used either as donor parents in breeding programs or production of further DH populations. These genotypes are from a doubled haploid DH population derived from Ducula-4/2* Brookton, varieties and breeding lines sourced from participating project partners
- further refinements of breeding objectives based on continued environmental characterisation and the demonstration of its interaction with genotypes during WL.

Germplasm evaluation was the major activity in 2003 for all partners. The project has provided Indian partners with access to germplasm produced in Australia that has moderate WL tolerance in reclaimed soils in India; these varieties are also well known for good grain quality in Australian environments. The identification of further tolerant genotypes to WL and sodicity continued with13 breeding lines reputed to have good tolerance to WL in sodic soil introduced from India for use as parental lines in production of new germplasm.

Plant breeding continues to be led by the Department of Agriculture, Western Australia (DAWA), with the development of both new, genetically fixed DH and segregating populations. Their distribution was coupled with statistical design to maintain uniformity and accuracy of field trials across partners. Good progress was also made with major breeding activities by two Indian partners (NDUAT and CSSRI) in 2003.

More than 200 genotypes were sown in over 4,000 pots to evaluate waterlogging tolerance and recovery ability under controlled conditions. Results demonstrate that WL accentuates the accumulation of high to toxic concentrations of some micronutrients in wheat seedlings in some WL prone soils in Australia and India. This occurs during long term WL due to severe reduction in soils, and increased solubility and uptake of reduced microelements by plants. The results so far have revealed that tolerance to aluminium (Al) might determine performance of wheat in some WL soils in

Significant evidence of differential tolerance to either manganese (Mn) or iron (Fe) and WL tolerance was not observed, although all tested genotypes had a moderate level of tolerance to Mn in Australia. The current hypothesis is that enhanced tolerance to Al confers an improved tolerance to WL in Australian soils, possibly by exclusion of Al which is more available during WL. Note that these results seem to be unique for Australian soils; preliminary results indicate an important role for other microelement toxicities (sodium and boron) in waterlogged soils of India.

Good progress has been made in evaluations of aerenchyma, and biochemical traits for recovery from anoxia and protection against oxidative damage. Some of the recommendations for waterlogging tolerant varieties generated through this project have already been communicated and extended to farmers in India.

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
	Email: p.salisbury@unimelb.edu.au
Collaborating Institutions:	Huazhong Agricultural University, China
	Institute of Industrial Crops, China
	Oil Crops Research Institute, China
	Haryana Agricultural University, India
	Indian Council of Agricultural Research, India
	National Research Centre on Rapeseed-Mustard, India
	Punjab Agricultural University, India
	Tata Energy Research Institute, India
	Department of Agriculture, Western Australia, Australia
	Department of Primary Industries, Victoria, Australia
	NSW Agriculture, Australia
	South Australian Research and Development Institute, Australia
	University of Western Australia, Australia
Project Budget:	$2,581,770
Project Duration:	01/01/2004 to 31/12/2008
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

China and India each grow over 6 million ha of oilseed Brassicas (*B. napus* (rapeseed) is dominant in China and *B. juncea* (Indian mustard) dominant in India). Both countries seek to replace traditional rapeseed and mustard cultivars with canola quality (low erucic acid, low glucosinolate) types. They value Australia's canola quality *B. napus*, which is better adapted to their countries than varieties from Europe or Canada. But a number of key diseases and environmental stresses limit oilseed Brassica production in India, China and Australia. This project will seek to develop *B. napus* and *B. juncea* germplasm with improved canola quality, disease resistance (*Sclerotinia* – white rust) and improved drought tolerance. The project will generate genetic data on economically important traits in crosses between lines of Australian, Indian and Chinese *B. napus* and *B. juncea*. Chinese and Indian scientists will improve their expertise in Brassica quality analysis and molecular genetics through training opportunities in Australia.

Project progress

The first annual report is due mid 2005.

CIM/2002/030: Improving subtropical 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 4155 6244 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:	$399,365
Project Duration:	01/01/2003 to 31/12/2005
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

In Sikkim a once thriving mandarin industry is in serious decline. Citrus remains the most important horticultural crop for Sikkim despite existing problems, but there is a large and lucrative market that cannot be captured under present conditions. The principle problem is thought to be huanglongbing, a debilitating insect-transmitted proteobacterium that has devastated citrus production in many parts of the tropics and subtropics. This project is attempting to develop techniques for increased productivity in the presence of the disease, by focusing on exploiting the extensive genetic diversity that exists within Citrus and related genera. Genetic material is being evaluated under subtropical conditions in Sikkim and Australia with the aim of identifying both scions and rootstocks that offer improved productivity.

Project progress

Year 1 (01/01/2003-31/12/2003)

A survey of farmers throughout all citrus growing regions of Sikkim sought to establish the relative importance of citrus production to the livelihood of local families, and the desire of people to grow this crop. Citrus has the potential to be the most profitable crop Sikkim farmers can grow, and they are eager to do so. However the tree decline problem has dramatically reduced yields and regions formerly dominated by citrus have gone completely out of production. The survey found that farmers were unable to do anything to combat the decline problem once it arrived in their area, and there was no evidence that the dramatic deterioration in tree health was in any way related to mismanagement. Some orchards with normal productivity were identified, and their superior performance might be explained in terms of clean planting material and isolation from infected areas.

A broad genetic base has been established in Sikkim, by the Sikkim Development Foundation, using material supplied from Queensland's citrus germplasm collection. More than 100 scion and rootstock genotypes were supplied as seed and grown in insect proof conditions at Tadong, Sikkim, where they have passed Indian quarantine requirements, and been distributed to different regions of the State. Their performance will be assessed over the coming years, while remaining material will be incorporated into rootstock and disease management experiments.

Molecular techniques were used to confirm the widespread distribution of the devastating citrus disease huanglongbing (formerly known as ‘Greening’). Samples were collected from orchards and nurseries throughout the citrus growing belt of Sikkim and processed in the North Australia Quarantine Strategy laboratory in Mareeba, Queensland.

Rootstocks for Eureka lemon are being examined in an experiment planted near Bundaberg, Queensland. Material includes some recently developed hybrids as well as citrus relatives never previously tested as rootstocks. Excellent growth has been achieved with the first crop expected in early 2005. An Imperial mandarin rootstock experiment has also been propagated and is being field tested. It includes some Chinese germplasm introduced in a former ACIAR project, and never previously evaluated under subtropical conditions. In addition, this experiment incorporates new material from rootstock breeding in Australia, South Africa and USA. Graft compatibility experiments are underway in both Sikkim and Australia, aimed at identifying genera that might be useful in future disease management strategies.

Good nurseries are critical to any commercial citrus industry, and are needed to supply vigorous high health status trees to farmers. Sikkim collaborators are developing their expertise in growing citrus with poor quality potting media has been identified as a major constraint. Potential ingredients for improved potting media are readily available and preliminary experiments with these ingredients have been conducted.

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 4916 3902 Email: stewart.fielder@fisheries.nsw.gov.au
Collaborating Institutions:	Central Institute of Fisheries Education, India Indian Council of Agricultural Research, India Murray Irrigation Limited, Australia
Project Budget:	$544,041
Project Duration:	01/01/2004 to 31/12/2006
ACIAR Research Program Manager:	Mr Barney Smith

Project background and objectives

Salinity and waterlogging, caused by rising water tables bringing both poor quality (saline) and good quality (waterlogged) water to the surface, are prevalent in parts of India and Australia. They render agricultural land unproductive or result in complicated management regimes to achieve viable yields. Utilising aquaculture in saline waters resulting from low aquifers, where water is pumped into holding ponds, is a possibility if properly managed. In India project work is examining stocking densities and management techniques for rearing and growing out great freshwater prawns from the larval stage. In similar conditions in Australia snapper will be trialled with the suitability of saline groundwater for several prawn species also examined. Suitable technologies for rearing these species will be trialled and developed.

Project progress

The first annual report is due early in 2005.

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 Timothy Grove Phone: 08 9333 6661 Email: Timothy.Grove@csiro.au
Collaborating Institutions:	Kerala Forest Research Institute, India Center for International Forestry Research, Indonesia Griffith University, Australia University of New South Wales, Australia University of Western Australia, Australia
Project Budget:	$1,468,869
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

The long-term capacity of plantations in many countries is being questioned, where the decline in soil fertility and tree productivity is often quite marked in successive generations. This is notable in India, which has the largest area in the world under eucalypt plantations. This project is seeking to identify and develop practices that improve silvicultural regimes and make best use of site resources. Studies are grouped into four subprojects: nutrient status and nutrient cycling; plant physiology and water relations: tree growth and nutrient uptake; soil process and growth modelling. The scientists will focus on the species *Eucalyptus tereticornis* and *E. grandis* in Kerala, India and on *E. globulus* in southern Australia.

Project progress

Year 6 (01/07/2002-30/06/2003)

The extension phase commenced in January 2003, six months after completion of the first phase of the project. Good progress has been made with key activities. The project commenced in 1997, when a set of comprehensive experiments was established at four locations with two eucalypt species (*Eucalyptus tereticornis* and *E. grandis*) in Kerala State, India.

Develop alternative eucalypt silvicultural systems for sustainable high production
The experimental sites continued to be maintained by periodic weeding, tracing fire lines and managing fences around the sites. The planned 5-year measurement of trees was slightly delayed (5.2 to 5.5 years) but was completed for 3 of the 4 sites within the reporting period. These measurements, together with those undertaken by KFRI in the 6-month period prior to the commencement of this extension phase have been important in providing time trend data on annual growth increments. The most recent measurements indicate that the largest responses continue to be to nutrient application and weed control. Maximum increases in productivity to combined treatments range from up to 75 per cent in *E grandis* to 110 per cent in *E tereticornis*.

Mean annual increments (MAI) in stem volume (over-bark) on the better treatments range from 23 m3/ha in I to 54 m3/ha in E grandis. Current annual increments (CAI) are similar to, or marginally higher, than the MAI for these better treatments, but are greater than MAI's on treatments with lower productivity. Consequently, the relative difference between the various silvicultural treatments is diminishing, although absolute differences in stem volume are generally being maintained or are increasing. A full analysis of the growth trends over time to harvest will be used as part of the economic analysis to determine the optimum rotation length, as well as the best treatment combinations. Destructive sampling of trees from specific nutrient treatments has also been

completed at 3 of the 4 sites. Measurements of dry matter and nutrient composition of tree components will be used to extend allometric and nutrient content relationships to provide tools to predict dry matter and nutrient accumulation and allocation within these stands.

Demonstrate improved site management techniques generated from the project research
The four study sites are located strategically in the major eucalypt plantation areas in Kerala. The current experiments have already proven to be a focal point for transfer of research results to the three main grower groups in the State—Kerala Forest Dept. (KFD), Kerala Forest Development Corporation (KFDC) and Hindustan News Print Ltd. (HNL). The project sites are frequently visited by officials from these three organisations and recently this has led to requests for collaboration from KFRI scientists and for provision of an interim set of management guidelines for improving productivity of their eucalypt plantations. The experiments are also encouraging small land-holders to introduce eucalypts into their farming systems to provide an additional source of income.

Continue training and capacity building at KFRI
Training is to continue in the extension phase, with KFRI scientists taking increasing responsibility for conduct of the project, the analysis and interpretation of research results and writing of research reports and scientific papers. This will be facilitated through continuing visits by CSIRO Project staff to Kerala and by the visit of three KFRI Project scientists to Perth.

Increase the international interactions of the project through the Center for International Forestry Research (CIFOR)
The initial phase of the project was part of the CIFOR network project on site management in tropical plantations, which includes scientists from Congo, South Africa, Indonesia, Vietnam, China, India, France, Brazil, USA and Australia. Broader international collaborations and exposure for the project will be greatly facilitated by the formal participation of CIFOR as Lead Overseas Collaborator to this extension phase. This participation has provided opportunity for transfer of research outcomes and interaction with colleagues from member countries of the CIFOR network.

FST/1998/096: Domestication of Australian trees for reforestation and agroforestry systems in developing countries

Overseas Collaborating Countries:	India, Indonesia, Laos, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam
Commissioned Organisation:	CSIRO Forestry and Forest Products, Australia
Project Leader:	Dr John Doran Phone: 02 6281 8319 Email: john.doran@csiro.au
Collaborating Institutions:	None
Project Budget:	$2,094,461
Project Duration:	01/01/2000 to 31/12/2004
ACIAR Research Program Manager:	Dr Russell Haines

Project background and objectives

In much of the developing world people face severe shortages of wood and other forest products. Many Australian tree species are widely grown in developing countries and can help to alleviate this problem. However, failure to use the best germplasm reduces the benefits that these plantations provide. This project builds on earlier ACIAR-funded research and aims to assist developing countries to achieve more effective use of Australian tree species. CSIRO scientists are providing seeds, information and technology to the collaborating countries, and identifying environmental and management factors necessary to improve seed yield and quality. The development of local supply bases of genetically improved seed in collaborating countries will ensure sustainability.

Project progress

Year 4 (01/01/2003-31/12/2003)

As in previous years, seed supply, provision of technical advice and literature, and training continued to be a main focus of the project. Research seedlots with a total weight of 10.5kg valued at $25,000 were sent to a total of 25 customers in 16 countries during the year. During 2003, seed collections to support the project focused on *Eucalyptus camaldulensis*, with extensive field trips to collect natural provenance seed in western Victoria and Queensland. Additionally seed of several species, including *Acacia crassicarpa*, *A. mangium* and *E. pellita*, was collected from seed orchards established in a previous project cycle.

Written technical advice on species and provenance selection, improved seed production, silviculture and utilisation of Australian species was provided by project staff to client organisations in many countries worldwide, with Cambodia, China, Ethiopia, Ghana, India, Indonesia, Kenya, Niger, Rwanda, Tanzania and Thailand prominent.

PHT/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 9385 4355 Email: r.driscoll@unsw.edu.au
Collaborating Institutions:	Central Mechanical Engineering Research Institute, Power Engineering and Heat Transfer Group, India
Project Budget:	$546,006
Project Duration:	26/06/2003 to 26/12/2006
ACIAR Research Program Manager:	Dr Greg Johnson

Project background and objectives

In West Bengal, drying of maize and rice is inefficient and unreliable. Current systems (some more than 20 years old) use energy inefficiently and reduce grain quality, failing to provide the service needed to modernise the region's grain industries. Attention to moisture removal during storage is inadequate, and quality thus deteriorates during storage and transport. This project is scoping, developing, testing and disseminating improved two-stage systems for drying grain to enhance local capacity to design, manufacture and manage grain-drying systems that benefit smallholders in West Bengal. Introduction of the improved systems will reduce losses, improve grain quality and enable economical and efficient drying of larger volumes of grain.

Project progress

Year 1 26/06/2003-25/06/2004

Survey of regional grain drying and manufacturing and selection of industry partner(s)
This work has been carried out by the CMERI project team in India and especially in West Bengal. The statistical data on grain and seed production (paddy, wheat, maize and oilseeds) have been obtained from West Bengal and other north eastern states.

The CMERI team has conducted a survey on seed farms on the storage conditions of seeds, with an emphasis on the relative humidity and temperature during storage and their effects on germination.

Grain processors, seed and feed industry were the main focus of the survey. Linkages have been established with the Department of Agriculture, Government of West Bengal. This organisation will provide the facilities for experimental studies at Bardhaman Seed Farm, near Durgapur. This work will be expanded to seed farms in other districts:

- Arambang Hatcheries Ltd (Feed plant)
- Indus Food Products and Equipment Ltd (drying equipment manufacturer).

An introductory seminar was conducted at CMERI in Durgapur. The seminar was attended by representatives of private industry (manufacturers of equipment as well as grain processors), research institutes and universities. Participants came not only from north eastern India but also from countries in the region with similar production patterns (Bangladesh and Thailand). The seminar was a platform for the introduction of the concept of two-stage drying and for the exchange of information on existing drying technologies for grain.

Development of computer-based drying models
The CMERI team has collected thermo-physical data including density, specific heat and thermal conductivity on main varieties of grain crops grown in north eastern India. Two members of the CMERI team visited the drying facilities of the UNSW in 2004 in order to get acquainted with the

methodology used for the acquisition of thermo-physical data and development of the existing mathematical models.

The CMERI team collected weather data on temperature and relative humidity from following regions:

- Gangetic West Bengal
- Sub-Himalayan West Bengal
- North-eastern States.

The UNSW team conducted an initial study on the effects of low temperature drying on seed quality, including viability, germination and vigour. A more comprehensive work including the effects of two-stage drying and model development is in progress.

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: 02 6960 1528 Email: Liz.Humphreys@csiro.au
Collaborating Institutions:	Punjab Agricultural University, India NSW Agriculture, Australia University of Melbourne, Australia
Project Budget:	$1,494,957
Project Duration:	01/01/2002 to 31/12/2006
ACIAR Research Program Manager:	Dr Christian Roth

Project background and objectives

Trials to grow rice in rotation with other crops using a system of permanent raised beds have recently shown promising results in Australia and South Asia. This project is investigating the major management requirements to grow these crops, where irrigation water is only supplied to inter-bed furrows. Rice plants on the beds have a portion of their root systems in unsaturated soil – the soil is never puddled as in traditional rice cropping. The scientists are conducting three major and several corollary experiments at Ludhiana, Punjab, India and one major experiment in southern New South Wales, Australia. The teams will monitor water, nitrogen and crop performance and adapt soil and crop simulation models to fit the permanent bed system, assisting progress in understanding the key processes of water and nitrogen movement and contributing to development of the new technologies.

Project progress

Year 2 (01/01/2003-31/12/2003)

Major experiments to compare permanent bed and conventional rice-wheat cropping systems in Punjab, India and rice-based systems in NSW, Australia, were established in 2002, and are now into their third crop (wheat in India, rice and soybeans in Australia).

The weather in Punjab 2002-03 was unusually foggy and cold mid-season, and rainfall was unusually high prior to heading. Yields of wheat on beds were comparable to yields on the flat at two sites with loam soils and lower on two sandy loam sites on the PAU farm at Ludhiana. The reasons for the poorer performance on beds relative to flats on the sandy loam at Ludhiana are unclear, and this result is in contrast with many reports of similar or better yields on beds. As the season was unusually wet, there was no effect of irrigation treatment on wheat growth or yield. Yields ranged from 3.5-3.6 t/ha on a reclaimed sodic soil where the crop suffered from lodging prior to heading due to storm damage, to 4.1-4.9 t/ha at the other sites.

Results from the 2003 rice season in Punjab showed no irrigation water savings on beds compared with puddled transplanted flats, and yield losses of 10-20 per cent for transplanted rice on beds compared with the recommended practice of puddled transplanted rice irrigated two days after the floodwater disappeared (PTR-2d). Yield loss was larger (around 30 per cent) with dry seeded rice on beds irrigated two days after the furrows had drained (DSRB-2d). Iron deficiency and nematodes contributed to yield loss on the beds, and hand weedings were required as chemicals did not provide adequate control. Irrigation water use was very high and ranged from 1,680 mm on PTR-2d on the loam to 4,950 mm for dry seeded rice on beds irrigated daily. Irrigation water use was roughly halved by irrigating two days after the floodwater had disappeared compared with daily irrigations to try and maintain continuous flooding in both PTR and beds.

Yields of 2002-03 rice on beds in Australia with continuous ponding between panicle initiation and maturity (10.1 t/ha) were significantly lower than yields on the flat (12.7 t/ha) due to the large gap (0.6m) between outside rows on adjacent beds. Input (irrigation plus rain) water use in these bed and flat treatments was similar (1,830 mm), and was reduced to 1,720 mm by maintaining water in the furrows only from PI to maturity. This resulted in a decline in yield to 9.4 t/ha and a reduction in water productivity from 0.68 to 0.55 g/kg. Land use after rice was wheat or fallow on flats and beds, and barley on beds only. Rice was sown on the fallowed beds in October 2003. The gap between outside rows on adjacent bets was narrowed to 0.3 m for the 2003-04 rice on beds by widening row spacing from to 0.22 m and sowing on the shoulders of the beds. Soybeans were sown on beds in December 2003 after barley harvest.

Soybean-wheat and maize-wheat field experiments were established in June 2003 in Punjab comparing bed and flat layouts and wheat straw mulching (6 t/ha) in the direct drilled treatments on beds and flats. There was no effect of layout or mulching on soybean (1.45 t/ha) or maize (5.5 t/ha) yields in 2003, a season with well-distributed rainfall, and as a consequence the soybeans only received one irrigation, while the maize was not irrigated.

A separate experiment evaluating the effect of straw mulching and N rate for rice-wheat on beds and flats in Punjab commenced in June 2002, and is now into its fourth crop (wheat). The soil is a sandy loam. In 2002-03, yields of rice and wheat on beds were lower than on flats, with large yield declines in the case of rice on beds, partly due to increased disease (brown leaf spot). These lower yields on beds on the sandy loam are consistent with the findings of sub-project 1. There was no effect of wheat mulch (3 t/ha) on rice yield, however yields of wheat mulched with rice straw (6 t/ha) were depressed at all but the highest N rate (160 kg N/ha). This experiment is being undertaken in collaboration with the IAEA Coordinated Research Project on integrated nutrient, soil and water management for rice-wheat.

A review of the performance of the CERES Rice and Wheat models showed that CERES Rice has generally performed well in its ability to predict anthesis and maturity dates in Asia. However, there are few reports of its ability to predict a wider range of parameters, and the few evaluations under water and N limiting conditions suggest that the model does not perform well under high stress conditions. Evaluation of CERES Rice in Australia has been limited and demonstrates the need for a chilling injury routine. Such a routine has been developed in the past but needs further revision and testing. The few evaluations of CERES wheat in the rice-wheat areas of Asia showed reasonable ability to predict anthesis and maturity dates and yield, but prediction of biomass is less reliable. There has been only one study evaluating the performance of the CERES rice-wheat sequence model under the DSSAT framework. In that study the sequential model performed fairly well in terms of yield prediction, but simulation of soil C and N was not realistic. Interaction with the developers of DSSAT and the CERES Wheat, Maize, Rice and SOYGRO models in the USA has increased to the level that hands on collaboration in model validation and applications has commenced.

The development of the Happy Seeder for direct drilling into stubble has continued to progress through additional funding from ACIAR and collaboration with Dasmesh Mechanical Works, Punjab, India. Trials established in 2002 at PAU Ludhiana showed good establishment and growth of wheat on flats and beds with up to 8 t/ha of rice straw mulch, although results in 2003-04 suggest that establishment is impaired with more than about 6 t/ha of mulch in some situations, but that sowing depth is also an important factor. Inspired by this work, a group in Pakistan has also commenced to make a Happy Seeder based on photos of the machine built in India.

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 Email: N.Menzies@uq.edu.au
Collaborating Institutions:	BAIF Development Research Foundation, India Indian Institute of Soil Science, India Department of Natural Resources and Mines, Queensland, Australia
Project Budget:	$998,595
Project Duration:	01/07/2004 to 30/06/2008
ACIAR Research Program Manager:	Dr Christian Roth

Project background and objectives

Farmers in Madhya Pradesh, India, face large soil nutrient deficits, resulting in the need for fertilisers to balance the soils. Farm yard manure (FYM) is plentiful and mainly used for fuel, as well as for fertiliser. More appropriate use could lessen the need for fertilisers. Farmers in south-eastern Queensland already use FYM from feedlots on nearby fields. Inappropriate use can and in some places is resulting in excessive levels of Nitrogen and Phosphorus, as well as acting as a pollutant. What is needed in both locations is better FYM utilisation based on relevant management techniques. The complementary skills of farmers can be combined and transferred between locations to increase the levels of manure nutrients reaching crops and better balance fertiliser deficits while minimising environmental risks.

Project progress

The first annual report is due mid-2005.

India: multilateral

AS2/1999/062: 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 Email: c.t.hash@cgiar.org
Collaborating Institutions:	International Livestock Research Institute, India
Project Budget:	$1,220,012
Project Duration:	01/01/2004 to 31/12/2008
ACIAR Research Program Manager:	Dr Bill Winter

Project background and objectives

Crop residues are a major source of ruminant feed in crop-livestock systems. To date, plant breeders have given little attention to the quality of this component of the crop. This project brings together plant breeders (ICRISAT) and livestock nutritionists (ILRI) to improve the quality of millet, a dual-purpose crop used widely by smallholder dairy farmers in India. About 70 per cent of millet is grown using commercial hybrid cultivars, utilising ICRISAT parent lines. This project will introduce higher quality attributes into some of the preferred parent lines and work with the private sector to conduct on-farm demonstrations of the new hybrids.

Project progress

The first annual report is due early in 2005.

LWR/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, IWMI South Asia, India
Project Leader:	Dr Christopher Scott Phone: + 91 40 2329 6161 Ext 2735 Email: c.scott@cgiar.org
Collaborating Institutions:	Jawaharlal Nehru Technological University, Centre for Water Resources, India University of Melbourne, Department of Civil and Environmental Engineering, Australia
Project Budget:	$1,120,240
Project Duration:	01/07/2004 to 30/06/2008
ACIAR Research Program Manager:	Dr Ian Willett

Project background and objectives

Water allocation issues in India's Krishna Basin are similar to those in Australia's Murray Darling Basin. In both cases several states share the basin and a central authority oversees water allocations. Water is extracted from the Krishna Basin for agriculture, industrial and domestic uses, with demand in all areas growing. The Indian Government has created the Krishna Basin Tribunal as the Basin's central authority to make allocations. The Tribunal relies on objective technical and economic information to make these allocations, with a new round expected in the next few years. An integrated framework to formulate and evaluate water allocation strategies will be developed, based on historical and hydrological data.

Project progress

The first annual report is due mid-2005.

Pakistan: bilateral

AS2/2001/029: Development of a knowledge system for the selection of forages for farming systems in the tropics

Overseas Collaborating Countries:	China, India, Indonesia, Pakistan, Philippines, South Africa, Vietnam
Commissioned Organisation:	CSIRO Sustainable Ecosystems, Australia
Project Leader:	Dr Bruce Pengelly
	Phone: 07 3214 2348
	Email: Bruce.Pengelly@csiro.au
Collaborating Institutions:	International Center for Tropical Agriculture, Colombia
	International Livestock Research Institute, Ethiopia
	Queensland Department of Primary Industries and Fisheries, Australia
	University of Queensland, Australia
Project Budget:	$837,717
Project Duration:	01/07/2002 to 30/06/2005
ACIAR Research Program Manager:	Dr Bill Winter

Project background and objectives

In the developing world sown tropical forages can provide part of the feed base to support the expanding market for livestock products. Forages can improve feed quality and quantity in a range of farming systems. However, adoption has been limited for a number of reasons, including poor access to appropriate information. Much of the important information is fragmented, unpublished or published in media of limited circulation. This project intends to synthesise and interpret what represents much of the accumulated information on species adaptation, use and management over the last 50 years from across the tropical world. It will be combined into one knowledge system (SoFT – Selection of Forages for the Tropics). The completed product will be a computer-based system that can be used to select 'elite' forage accessions tailored to specific farming systems and environments.

Project progress

Year 2 (01/07/2003-30/06/2004)

The development of a computer based selection tool and database is progressing. with the collaboration of a large number of forage experts from across the tropics and aims to deliver an expert system that will provide information on the management, use and variation between cultivars and elite accessions for over 120 major forage species for smallholder and large scale agricultural systems.

Develop a knowledge system for the identification of forages suitable for specified niches within smallholder farming systems
Nineteen attributes have been selected for use in the SoFT with between two and eight states in each attribute. Selection criteria available in the SoFT database for selecting the most suitable forages for environments and uses

Climate/farming system attributes	*Soil environment attributes*	*Plant attributes*
Latitude x altitude	Soil pH	Plant family (legume or grass)
Rainfall (average annual)	Level of available soil Al/Mn	Life cycle
Length of dry season	Level of soil salinity	Growth form
Inundation	Soil drainage	Stem habit

Intended forage use	Soil texture	Cool season growth
Grazing pressure	Soil fertility	Frost tolerance (foliage damage)
Shade environment		

SoFT selections are dependent upon the coding for each species in each attribute. This coding has been carried out by the Australian team members using their own experience in addition to the information from the workshops and literature reviews. The selection tool component of the database has been undergoing testing to ensure that selection outcomes are appropriate and that no obvious species are omitted

Each fact sheet in the database will have about 5 photos. So far over 1,000 high quality photos of forages have been sourced from forage scientists in Australia and overseas and have been placed in a database for filing and access. Photo subjects include juveniles, plants and forages being used.

Three workshops were held during the year at the of University of Hohenheim at Stuttgart Germany, in Cali, Colombia and in Hanoi, Vietnam, attended by more than 40 forage scientists. The workshop in Hanoi took place in conjunction with the annual meeting of the Forages for Smallholder Projects. Literature searches have continued and over 6,000 references have been assembled for the database.

Fact sheets have been written for about 70 of the most important fact sheets and a further 50 are expected to be completed before the database goes to press in March next year. These fact sheets are being written with a specific format and are of various lengths, depending primarily on the importance of the species.

Promote the system within the 'communities' who are using tropical forages
More than 70 agronomists have now attended project workshops across Asia, Africa, Central and South America, and Australia Negotiations are underway with FAO to have the database linked to their website and for FAO to be a distributor of the CD version. The project leader also plans to visit CABI in late 2004 to discuss the role of the database within their compendium system. The web version of the project will be housed on the CIAT website, with links from the CSIRO Sustainable Ecosystems website

Develop a strategy for maintenance and updating the knowledge system
Discussions with FAO and the project team about options for maintenance of the Database are continuing and it is proposed that FAO will take a leading role in partnership with CIAT to maintain the database. This arrangement will be crucial in ensuring that CIAT and others are equipped to deliver upgrades of the SoFT database.

CP/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: 08 8303 8634
	Email: ali.rezaian@csiro.au
Collaborating Institutions:	National Institute for Biotechnology and Genetic Engineering, Pakistan
	Asian Vegetable Research and Development Center, Taiwan
Project Budget:	$907,750
Project Duration:	01/01/2001 to 31/12/2004
ACIAR Research Program Manager:	Dr TK Lim

Project background and objectives

Severe epidemics of plant disease caused by geminiviruses have emerged in recent years. The upsurge in their occurrence is linked to the spread of their vector, the whitefly *Bemisia tabaci*. Epidemics in Pakistan during the 1990s have been especially severe, with huge losses in cotton and related industries, while in northern Australia the prospect of large losses through geminivirus of tomato is increasing. This project is undertaking a core study to define the extent of the problem in both countries. The long-term objective of the research, which is anticipated to extend beyond the scope of the initial project, is to characterise the main geminiviruses infecting cotton and tomato and to develop geminivirus resistance in both crops.

Project progress

Year 3 (01/01/2003-31/12/2003)

Field surveys of geminiviruses in Australia and Pakistan
Tomato leaf curl virus (TLCV) in Australia has now spread to Mossman where more intense vegetation, a high population of silverleaf whiteflies and the volume of traffic in the area is likely to contribute to further spread of TLCV to the major tomato growing regions.

A resistance breaking variant of the cotton leaf curl virus (CLCuV) in Pakistan has spread to several districts in the Punjab province. Analysis of viruses involved showed that, in addition to a geminivirus, a small satellite DNA (ssDNA) is present. Similar circular ssDNA satellites have recently been isolated from plants infected with other geminiviruses. The satellites, named DNA-alpha, depend on the helper viruses for their proliferation and, in turn, induce disease symptoms. The DNA associated with the resistance breaking variant is a recombinant of two DNA molecules isolated previously from cotton and tomato. Plants infected with the resistance breaking virus also contained recombinant of CLCuV and Okra yellow vein mosaic virus. Thus, viral recombination and mobilization of new viral components appears to be associated with a new epidemic of cotton leaf curl disease (CLCuD).

In other crops, CLCuV with a distinct DNA and tomato leaf curl New Delhi virus (ToLCNDV) were detected in chillies. ToLCNDV also causes widespread infection on cucurbits including squash, melon, muskmelon and watermelon. A severe disorder of melon was observed in the Punjab that was caused by a geminivirus/DNA alpha complex. Sequence analysis of DNAs isolated from Ageratum showing yellow vein disease indicated that CLCuV DNA and the DNA alpha of Ageratum yellow vein virus cause this disease.

Viral genome characterisation
Sequences analysis of 28 DNA alpha molecules revealed a highly conserved genome organisation. Two major groups of DNA alpha satellites were identified, one within the Malvaceae hosts and the second from plants within the Solanaceae and Compositae. The DNA sequence responsible for

inducing disease symptoms was confirmed. Further analysis of RNA from the transgenic plants identified one amino acid protein, responsible for symptom development.

Development of virus-resistant plants through genetic engineering:
RNA interference (RNAi) is a powerful tool for controlling gene expression. To induce RNA silencing against TLCV we transformed tomato plants with an intron-spliced hairpin sequence from TLCV and obtained transgenic lines producing high levels of small interfering RNA that is a hallmark of RNAi. Inoculation of these plants with TLCV resulted in attenuated infection.

Previously we showed that suppression of DNA alpha in transgenic *Nicotiana tabacum* protected plants against CLCuD. New constructs for simultaneous silencing of the viral DNA and DNA beta were tested in transient assay and were found to be effective. These constructs are being transformed in cotton and tobacco. RNAi constructs for ToLCNDV are being transformed in tomato. We also targeted the silencing of the CLCuV replication-associated protein as well as virulence determinant encoded by DNA and found these transgenes protect the plants from infection.

About 300 cotton genotypes and breeding lines at Vehari Research Station were analysed for resistance against CLCuV. A cotton genotype was found to remain completely virus free. In field trials no plants of transgenic cotton Coker-312 were infected with CLCuD while 100% untransformed control plants were infected. These results indicate that resistance in these lines is stably inherited. Seeds collected from these plants are being used for further field studies.

FST/1998/096: Domestication of Australian trees for reforestation and agroforestry systems in developing countries

Overseas Collaborating Countries:	India, Indonesia, Laos, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam
Commissioned Organisation:	CSIRO Forestry and Forest Products, Australia
Project Leader:	Dr John Doran Phone: 02 6281 8319 Email: john.doran@csiro.au
Collaborating Institutions:	None
Project Budget:	$2,094,461
Project Duration:	01/01/2000 to 31/12/2004
ACIAR Research Program Manager:	Dr Russell Haines

Project background and objectives

In much of the developing world people face severe shortages of wood and other forest products. Many Australian tree species are widely grown in developing countries and can help to alleviate this problem. However, failure to use the best germplasm reduces the benefits that these plantations provide. This project builds on earlier ACIAR-funded research and aims to assist developing countries to achieve more effective use of Australian tree species. CSIRO scientists are providing seeds, information and technology to the collaborating countries, and identifying environmental and management factors necessary to improve seed yield and quality. The development of local supply bases of genetically improved seed in collaborating countries will ensure sustainability.

Project progress

Year 4 (01/01/2003-31/12/2003)

As in previous years, seed supply, provision of technical advice and literature, and training continued to be a main focus of the project. Research seedlots with a total weight of 10.5kg valued at $25,000 were sent to a total of 25 customers in 16 countries during the year. During 2003, seed collections to support the project focused on *Eucalyptus camaldulensis*, with extensive field trips to collect natural provenance seed in western Victoria and Queensland. Additionally seed of several species, including *Acacia crassicarpa*, *A. mangium* and *E. pellita*, was collected from seed orchards established in a previous project cycle.

Written technical advice on species and provenance selection, improved seed production, silviculture and utilisation of Australian species was provided by project staff to client organisations in many countries worldwide, with Cambodia, China, Ethiopia, Ghana, India, Indonesia, Kenya, Niger, Rwanda, Tanzania and Thailand prominent.

LWR/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 5833 5283 Email: mike.morris@dpi.vic.gov.au
Collaborating Institutions:	National Agricultural Research Centre, Pakistan CSIRO Land and Water, Australia
Project Budget:	$807,554
Project Duration:	01/01/2004 to 31/12/2007
ACIAR Research Program Manager:	Dr Ian Willett

Project background and objectives

Traditional disposal into rivers of saline drainage effluent from irrigation farms in arid climates has become an increasingly important issue, and a problem for downstream users who rely on these rivers for water. The overall aim of the project is to develop systems for profitable and farmer-acceptable management of saline drainage effluent on irrigation farms. Scientists will identify crop and tree options suitable for irrigation with different drainage effluent salinities, grown in a *serial biological concentration system,* and will also trial fish and seaweed species suitable for cultivation in saline drainage effluent. Other facets include investigation of appropriate evaporative salt harvesting technology and development of models describing salt movement through biological concentration chains. Development of extension materials will facilitate adoption of the technology at both the professional management level in the irrigation industry and at the farm level.

Project progress

The first annual report is due in early 2005.

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, Western Australia, Australia
Project Leader:	Mr Greg Hamilton Phone: 08 9368 3276 Email: ghamilton@agric.wa.gov.au
Collaborating Institutions:	Pakistan Agricultural Research Council, National Agriculture Research Centre, Pakistan
Project Budget:	$395,374
Project Duration:	01/01/2004 to 31/12/2006
ACIAR Research Program Manager:	Dr Christian Roth

Project background and objectives

In Pakistan the practice of irrigated maize-wheat cropping on permanent raised beds has been shown to save water and increase yields (LWR/1998/131). In Western Australia's dryland cropping the potential benefits of raised bed cropping were inconclusive. Irrigated cropping dominates Pakistan's agriculture. Despite this grain yields are low and water is used inefficiently. Salinity and sodicity are on the rise. New research will seek to optimise the raised bed system in Pakistan. This will focus on soil management and impacts caused by the new system, and the best-bet technology for raised beds, including low-cost machinery. Cluster groups will be involved in seeking adoption. In Western Australia the role of beds in saline conditions will be modelled for potential benefits.

Project progress

The first annual report is due early in 2005.

Bangladesh: bilateral

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

Overseas Collaborating Countries:	Bangladesh
Commissioned Organisation:	University of Western Australia (Centre for Legumes in Mediterranean Agriculture), Australia
Project Leader:	Professor Kadambot H M Siddique
	Phone: 08 9380 7012
	Email: ksiddiqu@fnas.uwa.edu.au
Collaborating Institutions:	Bangladesh Agricultural Research Institute, Bangladesh
	International Crops Research Institute for the Semi-Arid Tropics, India
	Department of Agriculture, Western Australia, Australia
	Department of Primary Industries, Victoria, Australia
	NSW Agriculture, Australia
	University of Melbourne, Australia
Project Budget:	$725,328
Project Duration:	01/07/2002 to 23/11/2006
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

Botrytis Grey Mould (BGM), considered the most important foliar disease of chickpeas in Bangladesh, has caused a substantial decline in chickpea production over the past decade. Diminishing production has resulted in resource-poor farmers no longer having access to a cheap supply of high quality protein in their diets and Bangladesh becoming dependent on imported chickpeas (55,000 tonnes in 1999). In Australia, BGM is the second most important foliar disease after Ascochyta blight. Outbreaks are sporadic but damaging. Seed dressings and multiple fungicide applications can control BGM but this practice is unsustainable in Australia and economically non-viable in Bangladesh. An integrated disease management (IDM) approach is considered the best long-term control strategy. The project will evaluate integrated BGM management packages on an operational scale on-farm in both countries. Also a wide range of chickpea germplasm (including closely related wild *Cicer* species) will be evaluated for resistance to BGM under field conditions in Bangladesh and Nepal to provide a sound basis for genetic enhancement of host plant resistance to BGM.

Project progress

Year 2 (01/07/2003-30/06/2004)

The project achieved a second year of field screenings of 208 chickpea germplasm lines (including 101 new entries) at two field sites in Bangladesh. Both BGM field nurseries were exposed to natural disease development. The nursery at Ishurdi received regular watering to increase humidity and accelerate BGM development. Consequently, the final disease development was higher at Ishurdi and moderate disease developed at Jessore. Yields in excess of 100 g/plot (single row 2 m long) were achieved from 77 of the lines. There was general agreement between the BGM disease scores and plot yields observed when averaged across the two field screening nurseries, this revealed a trend for entries with higher disease scores to have lower plot yields.

Four hundred and twenty four chickpea germplasm and advanced breeding lines from Australian partners, screened in field nurseries in Bangladesh in 2002-03, were evaluated for resistance to BGM

and Ascochyta blight in a controlled environment at ICRISAT, India. None of these lines were observed to be immune or resistant to BGM. One hundred and eight entries were observed to be moderately resistant, whereas 261 were susceptible and 39 highly susceptible. Screening of advanced selections and varieties of chickpea was also undertaken at Department of Primary Industries, Victoria at Horsham. In 2003-04 138 entries were screened through these glasshouse tests, the majority of these lines were moderately susceptible, only 2 per cent were moderately resistant and no entries were rated as resistant.

In 2003 a collection of 63 isolates of Botrytis cinerea were made from four sites in Bangladesh with the aim of providing a structured hierarchical sample. These isolates have since been returned to Melbourne University for molecular analysis. The results have indicated the lack of population differentiation and revealed potential gene flow between individual sites in Bangladesh. The molecular analysis will continue with a further 168 isolates from chickpea collected in Bangladesh and 23 isolates from chickpea collected from locations in Nepal and India.

A participatory varietal selection programme for chickpea was initiated to facilitate farmers' input into the selection and breeding process for this BGM prone region. Trials were assessed by farmers at, Boira and Ishan Gopalpur, with two chickpea genotypes assessed in field and in on-farm evaluations. Barichola 5 was preferred over 'local' in both trials and evaluations.

On-farm evaluations of integrated crop management (ICM) packages by farmers and on-farm trials of ICM components were conducted at several sites in the five districts in Bangladesh which suffer the greatest impact of BGM. On-farm evaluations comprised farmer-managed operational scale plots comparing an ICM package with normal farmer practice. One hundred evaluations were established in selected districts. Plots of ICM and its accompanying normal practice plot were established side-by-side, and at the same time, during late November to mid-December. Grain yields exceeding 1 t/ha were realised in most of the ICM plots and were generally substantially higher in ICM plots than 'normal farmer practice' plots, but only where Barichola 5 was used as the improved variety. Chickpea yields exceeding 1 t /ha are required for the crop to be economically competitive with other Rabi season crops, including irrigated rice and wheat. The 2003-04 chickpea crop was subject to relatively low incidence of BGM and pod borer, nonetheless variability of yield in ICM plots was relatively high so it remains a risky crop in the view of farmers.

In Bangladesh, on-farm training in BGM and pod borer identification and management was given to all participating farmers and Block Supervisors during 2004. Subsequently, farmers applied foliar fungicide and insecticide to ICM plots, however, some farmer practice plots also received bird perches, foliar fungicide and insecticide sprays, practices which were expected to only be applied to the ICM plots. The farmers were apparently not convinced of the need of the scientists to record yields in the absence of improved management and wanted to immediately adopt what they considered as improved management. Farmers appear willing to adopt improved practices, particular improved varieties and BGM and pod borer management, as soon as they are familiar with those technologies.

LWR/1998/003: Arsenic transfer in water–soil–crop environments of Bangladesh and Australia

Overseas Collaborating Countries:	Bangladesh
Commissioned Organisation:	University of South Australia, Centre for Environmental Assessment and Remediation, Australia
Project Leader:	Professor Ravendra Naidu
	Phone: 08 8302 5041
	Email: Ravi.Naidu@unisa.edu.au
Collaborating Institutions:	University of Dhaka, Bangladesh
	Department of Environment and Heritage, South Australia, Australia
	University of Ballarat, Australia
Project Budget:	$784,300
Project Duration:	01/01/2000 to 30/06/2005 (Project extended from 01/07/2004 to 30/06/2005)
ACIAR Research Program Manager:	Dr Ian Willett

Project background and objectives

In Bangladesh and West Bengal, India studies have shown that the arsenic found in groundwater may be consumed by humans from several sources - drinking water, cooking water and from irrigated food crops. Thirty years of irrigation appear to have caused diffuse contamination of the soil with arsenic. The major focus of this project is assessing the extent and severity of arsenic contamination of soils at contrasting sites, to develop an understanding of the fate and behaviour of arsenic in soils, and to determine the water-soil-plant arsenic transfer coefficient in glasshouse and field studies. Project scientists are using the findings to develop methods of minimising arsenic uptake by plants and where possible to develop strategies to remediate contaminated soils, thus reducing the chance of arsenic poisoning in humans and animals. The project will also study areas in Australia that have some environmental contamination from arsenic.

Project progress

Year 4 (01/01/2003-31/12/2004)

Sampling and analyses of soils, plants and water continued in both Australia and Bangladesh with key towns and villages in both countries having been identified as key sites requiring further in-depth sampling. Along with these activities research was conducted at CSIRO Land and Water, Adelaide to further investigate the behaviour of arsenic in soils under laboratory conditions, the impact of microbial activity on arsenic speciation in alkaline soils as well as determining the human bio-accessibility of arsenic in selected contaminated sites for risk assessment predictions. Further studies were also conducted under glasshouse conditions to investigate the potential phytotoxicity of arsenic to commonly grown garden vegetables in several major South Australian soil groups.

Research in highly contaminated soils revealed that arsenite is the dominant arsenic species present in highly alkaline soils and that this process may be controlled by abiotic rather than biotic processes. Studies of approximately 42 soils collected from various arsenic contaminated sites in South Australia and Victoria revealed that the bio-accessibility of arsenic contaminated soil is generally less than 50 per cent of the total arsenic content of the soil. This has important implications when quantifying the exposure pathways and the risk associated with arsenic contaminated sites.

The University of Ballarat continued to build an extensive database on a further two highly contaminated areas of central Victoria which are undergoing rapid changes in land use. This database will later be transferred onto a GIS mapping package to be used by regulators, farmers and the community. The major findings from this extensive survey were that there is considerable off-site migration of arsenic downstream of the contaminated site which is continuing today. This has led to a

significant increase in the area of land outside the contamination source which contains elevated concentrations of arsenic and may be being utilized for other agricultural purposes.

In Bangladesh, three villages were identified for further extensive sampling; these being in the Munshigang, Narayanganj and Comilla districts. These three districts have a well documented history of patients presenting with symptoms of arsenocosis at the Dhaka Community Hospital. At each village soil, plant and groundwater samples were collected and analysed for arsenic content. Speciation of groundwater samples revealed arsenic present as arsenite and concentrations ranging between 5 and 800 mg L^{-1}. The current Australian drinking water standard for arsenic is 7 mg L^{-1} . Analyses of soil samples collected from agricultural areas around each village found that soil concentrations of arsenic were generally less than 20 mg kg^{-1}.

However, examination of arsenic content of crops from these sites revealed appreciable bioaccumulation of arsenic that ranged from less than 0.1 to greater than 20 mg kg^{-1} indicating that irrigation groundwater may be a significant source of arsenic for the crops. Glasshouse studies were conducted for a select number of crops which have shown to accumulate arsenic. Studies revealed that arum consistently accumulated higher concentrations of arsenic than other crops studied irrespective of the environmental conditions the crops were grown in. The addition of organic manures were shown to have little or no effect on the accumulation of arsenic but the addition of low levels or phosphate fertiliser (20 kg P ha^{-1}) increased the amount of arsenic accumulated while elevated additions of phosphate (40 kg P ha^{-1}) decreased the accumulation of arsenic by the crops studied.

Bangladesh: multilateral

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
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Collaborating Institutions:	Centre for Legumes in Mediterranean Agriculture, Australia
	Department of Primary Industries, Victoria, Australia
	NSW Agriculture, Australia
	University of Adelaide, Australia
Project Budget:	$398,915
Project Duration:	30/06/2004 to 30/06/2007
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

Food legumes provide high quality protein at low cost. During growth these crops fix nitrogen and reduce inoculum build-up of cereal diseases. Chickpeas, faba beans and lentils are important in West Central, South and East Asia and North Africa. Diseases, however, are a major constraint to productivity and despite recent improvements further yield increases and greater sustainability of production are possible. Diseases, biology and host resistance are being examined through germplasm screenings to help identify new sources of disease resistance. This will also inform the development of disease management packages to be evaluated in farming systems. Benefits from better disease resistance and disease management technologies for lentil, chickpea and faba bean will flow into the ACIAR mandate region in two main ways. ICARDA has many networks and collaborative projects for improvement of these crops in Asia and distributes better technologies and the products of its breeding programs to Afghanistan, Bangladesh, Bhutan, China, India, Korea DPR, Korea Rep, Nepal, Sri Lanka, Thailand, Vietnam. Benefits will also flow to Asia from a range of ACIAR projects which involve pulse improvement in Nepal, China, Bangladesh, India, Afghanistan and Iraq.

Project progress

The first annual report is due mid-2005.

Other South Asian countries: bilateral

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, Syria
Commissioned Organisation:	University of Western Australia (Centre for Legumes in Mediterranean Agriculture), Australia
Project Leader:	Dr Clive Francis Phone: 08 9380 2505 Email: cfrancis@cyllene.uwa.edu.au
Collaborating Institutions:	Nepal Agricultural Research Council, Nepal International Center for Agricultural Research in the Dry Areas, Syria Agriculture Victoria, Australia Birchip Cropping Group, Australia
Project Budget:	$520,422
Project Duration:	01/07/2001 to 30/06/2005 (Project extended from 01/07/2004 to 30/06/2005)
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

Lentils and another legume called grasspea (*Lathyrus sativus*) are widely grown in the lower areas of Nepal. Lentils are of considerable economic and nutritional importance to the country but yields could be improved by finding germplasm better adapted to 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 is selecting and propagating improved varieties of both species. Work will also take place in Australia, and any lentil varieties produced will be suitable for Australian conditions.

Project progress

Year 3 (01/07/2003-30/06/2004)

A good season in Australian in 2003 and in Nepal 2003-04 will see the completion of the GxE analysis with a three-year set of data from seven sites. The poor performance of Australian adapted Cumra was evident. Of special importance to the mid hills region were the high yields of ILL6829 and ILL7537, which mirrored the earlier results. Every effort should be made to fast track their release.

Farmer participation has helped in developing systems for rapid uptake of new cultivars. Seed has been provided at low cost to farmers for on farm evaluation. The system employed to further the release of ILL7723 for large scale plantings in 2004-05 has also seen the approval for the same process to apply to ILL2580 a line broadly adapted throughout the Terai and successful particularly in the relay rice system. Other promising lines include ILL7982 (with wilt and Stemphyllium resistance) and ILL6829 (for the mid hill). These require additional farmer exposure prior to release.

In terms of community Impact, the project should directly result in the release of a new cultivar of lentil (ILL7723) for the Terai of Nepal. In all 16 tonnes of seed produced by participatory farmers and on research stations will potentially see a rapid uptake of the new cultivar—far surpassing that of previous releases. Besides resistance to wilt, it also has a significant degree of resistance to rust and Stemphyllium blight and promises to be an important cultivar for the major lentil-growing region of the Western Terai.

Vascular wilt caused by *F. oxysporium f. sp. lentis* continues to be an important disease of lentil in Nepal and is aggravated by the increasing frequency of lentil cropping to meet demand and good prices received by the farmers. The only realistic method to control the disease is the use of resistant varieties. These are emerging as a result of the evaluation conducted in the ACIAR project and promise to be one of its major successes. Two lines (Digger (ILL5722), ILL1704) were rated highly resistant, 38 lines and varieties were rated resistant and 53 were recorded as moderately resistant. An important result was that the new line ILL7723 scheduled for release is rated at resistant. ILL 7982, under consideration for release in the mid hills, was also rated as resistant as was ILL7979 another promising variety for the mid hills. ILL4402 and ILL 2580 proposed for the whole of the Terai, and ILL6829 for the mid hills had moderate degrees of resistance. ILL7537, shown to have a high degree of resistance to Ascochyta blight in Australia in the first stage of the ACIAR project, is also rated resistant to wilt in the current series. This is a potentially important result for the Australian National Breeding Program as the line is being used widely in crosses.

Relay sowing of legumes into standing rice is common in the Indian sub-continent, often resulting in waterlogging of any under sown (relay) crops. Grass pea is reputedly more tolerant to this system than lentil - the favoured crop in Nepal. Glasshouse research in Perth and field trials in Nepal confirmed this. Low ODAP (a toxin) lines CLIMA 1 and CLIMA 2 are earlier and have been most promising in row evaluation at Rampur where they were sown for the first time—essentially for seed increase (R K Neupane). In addition, earlier maturing low lines from Bangladesh Bari Khesari 1 and Bari Khesari 2 were forward to NARC for evaluation against the well-adapted local line Sarlahi.

CP/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 Email: D.Drew@griffith.edu.au
Collaborating Institutions:	Ministry of Agriculture, National Plant Protection Centre, Bhutan
Project Budget:	$81,598
Project Duration:	01/01/1999 to 31/12/2004 (Project extended from 01/01/2001 to 31/12/2004)
ACIAR Research Program Manager:	Dr TK Lim

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 aims to conduct a fruit fly survey to identify pest species and define which of those species are causing crop losses. In addition, scientists will develop techniques for using protein bait sprays and instruct local personnel in the identification of fruit flies and application of bait sprays.

Project progress

Year 5 (01/01/2003-31/12/2003)

With the approval of ACIAR, the project was put on hold for the year 2003. This was due to the rapid development of a severe citrus dieback problem in Bhutan which took all of their personnel and other resources. The project resumed in April 2004 with the onset of the new mandarin fruiting season.

A progress report is due early in 2005.

FIS/2001/030: Management strategies for enhanced fisheries production in Sri Lankan and Australian lakes and reservoirs—extension project

Overseas Collaborating Countries:	Sri Lanka
Commissioned Organisation:	Deakin University, School of Aquatic Science and Natural Resource Management, Australia
Project Leader:	Professor Sena De Silva Phone: 03 5563 3527 Email: sena@deakin.edu.au
Collaborating Institutions:	Kelaniya University, Sri Lanka National Aquaculture Development Authority, Sri Lanka National Aquatic Resources Agency, Sri Lanka University of Paradeniya, Sri Lanka
Project Budget:	$246,542
Project Duration:	01/01/2001 to 30/06/2005 (Project extended from 01/01/2005 to 30/06/2005)
ACIAR Research Program Manager:	Mr Barney Smith

Project background and objectives

An earlier project (FIS/1994/040) developed a yield predictive model for capture fisheries in perennial tropical reservoirs based on geographic information systems (GIS). The model is destined to be a valuable management tool to enhance fisheries production in Sir Lankan and Australian reservoirs. This three-year extension is designed to capture substantial additional benefits from this research in support of national efforts to boost fish production and improve livelihoods in inland regions. The GIS model will be further tested and refined in Sri Lanka, and the knowledge of the model and its application transferred to national inland fisheries managers. The project team will develop a set of criteria, in partnership with local communities, to assess the suitability of seasonal tanks for a culture-based fishery. Other components will include studies of fry nursing in perennial reservoirs to provide fingerlings to stock seasonal tanks.

Project progress

Year 3 (01/01/2003-31/12/2003)

Capture fisheries
This component was completed in year 2002, and the recommendations are currently being implemented by the national Aquaculture Development Authority in the management of the fisheries in the large, perennial reservoirs.

Culture-based fisheries
Forty four non-perennial reservoirs were stocked (three species combinations and three stocking densities) over two culture cycles and the growth of the stock, yields and the limnology (physical, biological and geographical properties) of each of the reservoirs were monitored. In addition, the size of each of the non-perennial reservoirs used in the study together with their catchments was determined using GPS and 1:50,000 scale maps. The land use patterns of the latter were determined using satellite imagery and confirmed with random ground-truthing.

Of the 44 reservoirs stocked data could be obtained only from 36; that from the other eight being unreliable. The yield data and the growth data are being analysed and it is believed the study will enable the development of a best-practice model, incorporating water quality features, stocking density, species combination and the socio-economic conditions of the village community, for culture-based fisheries in Sri Lanka. Socio-economic criteria and biological criteria were incorporated into the model using the Analytical Hierarchical Process.

The project activities have brought about cooperation and integration between governmental departments that have jurisdiction over the utilisation of the water bodies, namely the Department of Agrarian Services and National Aquaculture Development Authority. Consequently, the Agrarian Services Statue will be amended to permit fishery activities in non-perennial reservoirs which hitherto had no legal status and hindered further fisheries developments.

Extension booklets on the technical and management aspects on culture-based fisheries were developed and provided to all the stakeholders. In the preparation of the material extensive consultations were held with all stakeholders, and the material is being utilised by the national aquaculture Development Authority in its endeavours to popularise the activity.

A workshop in 2002 on culture-based fisheries brought together governmental officials responsible for management of non-perennial reservoirs, agricultural extension in the command areas, fishery extension officers and aquaculturists and the practitioners. The overwhelming consensus at the workshop was that the project has stimulated the development of a new and useful activity for the community and that culture-based fisheries development should be extended to other regions in the country.

FST/1998/096: Domestication of Australian trees for reforestation and agroforestry systems in developing countries

Overseas Collaborating Countries:	India, Indonesia, Laos, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam
Commissioned Organisation:	CSIRO Forestry and Forest Products, Australia
Project Leader:	Dr John Doran Phone: 02 6281 8319 Email: john.doran@csiro.au
Collaborating Institutions:	None
Project Budget:	$2,094,461
Project Duration:	01/01/2000 to 31/12/2004
ACIAR Research Program Manager:	Dr Russell Haines

Project background and objectives

In much of the developing world people face severe shortages of wood and other forest products. Many Australian tree species are widely grown in developing countries and can help to alleviate this problem. However, failure to use the best germplasm reduces the benefits that these plantations provide. This project builds on earlier ACIAR-funded research and aims to assist developing countries to achieve more effective use of Australian tree species. CSIRO scientists are providing seeds, information and technology to the collaborating countries, and identifying environmental and management factors necessary to improve seed yield and quality. The development of local supply bases of genetically improved seed in collaborating countries will ensure sustainability.

Project progress

Year 4 (01/01/2003-31/12/2003)

As in previous years, seed supply, provision of technical advice and literature, and training continued to be a main focus of the project. Research seedlots with a total weight of 10.5kg valued at $25,000 were sent to a total of 25 customers in 16 countries during the year. During 2003, seed collections to support the project focused on *Eucalyptus camaldulensis*, with extensive field trips to collect natural provenance seed in western Victoria and Queensland. Additionally seed of several species, including *Acacia crassicarpa*, *A. mangium* and *E. pellita*, was collected from seed orchards established in a previous project cycle.

Written technical advice on species and provenance selection, improved seed production, silviculture and utilisation of Australian species was provided by project staff to client organisations in many countries worldwide, with Cambodia, China, Ethiopia, Ghana, India, Indonesia, Kenya, Niger, Rwanda, Tanzania and Thailand prominent.

PHT/1997/094: Management of postharvest diseases of subtropical 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 3896 9468 Email: lindy.coates@dpi.qld.gov.au
Collaborating Institutions:	Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, Philippines University of the Philippines at Los Banos, Philippines Department of Agriculture, Sri Lanka University of Peradeniya, Sri Lanka
Project Budget:	$727,000
Project Duration:	01/07/2002 to 31/12/2006 (Project extended from 01/07/2004 to 31/12/2006)
ACIAR Research Program Manager:	Dr Greg Johnson

Project background and objectives

This project will improve strategies for managing postharvest diseases of subtropical and tropical fruit which frequently cause >20 per cent losses. Current controls do not reliably control disease during retail marketing and export. The research exploits the fact that while fungal infection occurs during fruit development, plant defence mechanisms inhibit extensive invasion. Sri Lankan and Australian scientists are characterising resistance mechanisms (Sri Lanka; mango and banana, Australia; mango and avocado). The project was extended in July 2004 to include Philippines researchers, and researchers and agriculturists in Australia, Sri Lanka and the Philippines are now testing treatments and working with farmers to enhance resistance and thus suppress disease development on mangoes during production and marketing.

Project progress

Year 2 (01/07/2003-30/06/2004)

Host defence mechanisms in mango and avocado fruit (Sri Lanka and Australia)
In Sri Lanka, one antifungal fraction of mango peel extract has been tentatively identified as a mixture of galloyl tannins with glycosidic linkages. Galloyl tannins have previously been isolated from other plant species and have been shown to possess antifungal activity.

In both Australia and Sri Lanka, differences were found in the resistance of several mango cultivars to anthracnose. Peel and sap samples have been taken from the different cultivars for analysis of antifungal resorcinols. In both countries it was also found that non-de-sapped mango fruit had lower levels of postharvest disease (anthracnose and stem-end rot) than de-sapped fruit, suggesting that sap plays a role in mango disease resistance.

Withholding nitrogen fertiliser or delaying application until late in fruit development resulted in lower anthracnose levels in Keitt mango fruit, compared to fruit from trees receiving earlier applications of nitrogen. Peel samples from this trial are currently awaiting analysis for resorcinol levels.

Preharvest applications of acibenzolar-S-methyl (Bion) did not significantly reduce anthracnose levels in Kensington Pride mango fruit. However, there was a trend showing less anthracnose in acibenzolar-S-methyl treated fruit compared to control fruit.

In preliminary studies, rootstock choice was shown to influence the susceptibility of Kensington Pride mangoes to anthracnose.

In avocado, peel samples were taken from Hass fruitlets sampled at several different stages of fruit development. These are to be analysed for antifungal diene levels in the coming months. Attempts will be made to correlate this data with differences in the susceptibility of avocado fruit to infection by *C. gloeosporioides* (the anthracnose and pepper spot pathogen) at different stages of fruit maturity.

Freckle-induced resistance in banana fruit (Sri Lanka)
Local banana cultivars exhibited differential susceptibility to freckle disease and anthracnose in Sri Lankan studies. The cultivar "Puvalu", which is highly susceptible to freckle, was found to accumulate high levels of phytoalexins following severe infection by the freckle fungus. As a result, this cultivar is highly resistant to anthracnose. The cultivar Seeni, however, which is resistant to both freckle and anthracnose, was found to contain a preformed antifungal substance that was not detected in any other cultivars tested. Chemical analysis of the phytoalexins induced by freckle infection is underway.

Freckle infection was also shown to delay the respiratory climacteric peak and ripening of fruit compared to non-freckled fruit, as well as significantly increasing pH of the fruit peel in all commercial cultivars tested.

Harvested banana fruit cultivars of Embul, were sprayed with different concentrations of the defence activators salicylic acid (SA) or acibenzolar-S-methyl (Bion), and inoculated 72 hours later with *Colletotrichum musae*. SA (1000 mg/l) and Bion (400 mg/l) treatments significantly reduced anthracnose development compared with controls.

Research capacity enhancement
Three research students from the University of Peradeniya (Sri Lanka) visited DPI&F (Indooroopilly and Mareeba) in January 2004 to undergo research training. One of the QDPIF team visited the University of Peradeniya in June 2004 and provided research methodology training to the Peradeniya group, particularly in pathogen isolation, identification and field trials. A two day workshop was presented at the Postgraduate Institute of Science (University of Peradeniya) on *Postharvest handling and disease control in fruit* to project collaborators as well as participants from industry and other institutions

Other South Asian countries: multilateral

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

Overseas Collaborating Countries:	Afghanistan
Commissioned Organisation:	International Maize and Wheat Improvement Center, Rainfed Wheat Systems Program, Turkey
Project Leader:	Dr Hans-Joachim Braun Phone: + 90 312 2873595 Email: H.J.Braun@cgiar.org
Collaborating Institutions:	International Maize and Wheat Improvement Center, Afghanistan
Project Budget:	$1,000,000
Project Duration:	01/07/2004 to 30/06/2007
ACIAR Research Program Manager:	Dr Tony Fischer

Project background and objectives

A joint ACIAR/AusAID project ensured seed was available and introduced improved wheat and maize varieties to Afghanistan beginning in 2002. This was a short-term response to a lack of seed. Improvements to germplasm to ensure self-sufficiency are still needed. Wheat is the most important crop and maize the third most important. Germplasm that is suited to production systems of smallholder farmers will be identified and introduced, following verification tests in farmers' fields. Quality seed will be multiplied to ensure supply in future years. Improved management practices for existing and new varieties will be developed and introduced, focusing on plant establishment, weed controls, water and soil fertility management and conservation tillage.

Project progress

The first annual report is due mid-2005.

Concluded projects

1 July 2002 – 1 December 2004

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ADP/2002/049: Outlying developing countries in world food consumption patterns 77

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Other South Asian countries: multilateral

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CIM/2000/066: Host resistance, epidemiology and integrated management of faba bean, chickpea and lentil diseases (Bangladesh, India, Nepal, Pakistan) 105

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SMCN/2002/028: Stress tolerant wheat and maize for Afghanistan: Seeds of strength (Afghanistan) 109

India: bilateral

ADP/2002/049: Outlying developing countries in world food consumption patterns

Overseas Collaborating Countries:	China, India
Commissioned Organisation:	University of Western Australia, Faculty of Economics and Commerce (UWA Business School), Australia
Project Leader:	Professor Kenneth Clements Phone: 08 6488 2898 Email: ken.clements@uwa.edu.au
Project Budget:	$25,000
Project Duration:	01/01/2003 to 20/09/2003
ACIAR Research Program Manager:	Dr Ray Trewin

Project background and objectives

Increasing population and food security issues are important factors in food consumption patterns. Comparisons of patterns reveal trends and improve understanding of the dynamics driving consumption, upon which policy is based. However, these dynamics are not always uniform between countries, possibly skewing global trends and creating policy implications within countries. The project compared international patterns to identify consumption regularities and compare these to Chinese and Indian patterns. This enabled the researchers to determine if the two countries fit global norms or are outliers (statistically different from the global norm). Such a determination would have significant policy impacts, given the large populations of both countries. If either or both are outliers this has ramifications that could skew decision and policy-making, both in-country and also for decisions based on world consumption patterns.

Project outcomes

The project began by comparing international consumption patterns, using food purchases. Cross-country patterns were then examined against food consumption patterns. Two groups were defined based on GDP; rich countries with a GDP of at least 50 per cent of the USA, and poor countries with a GDP below this. Forty three countries were used in this division. This revealed consumption patterns (based on 'baskets' of food purchases) become more diversified as income rises. Non-food and food consumption patterns are reversed, as consumers in rich countries concentrate on non-food items. This reveals that as incomes rise expenditure on food decreases proportionately by total income.

At the aggregate level China and India appear to follow international norms of food consumption. Cross-country patterns were based on an Engel function relating the budget share of a commodity to total household expenditure. There is no important difference in food consumption patterns (based on food being a normal good for all income groups and regions) by region. Food is the dominant good by budget share, with food as a share of budget rising with falls in GDP per capita. Income increases result in less proportionally being spent on food - this being the global norm.

Food necessities in Asia (cereals, meats, fruits and vegetables, dairy products and oils and fats) are common, though dietary intake varies by country, with some more valued than others in different cultures. Despite this both China and India display traits, when analysed against other countries in the region, of fitting global norms. Further study of the specifics of diets and norms by country may reveal more about future trends.

AS1/1994/022: Prolific worm-resistant meat sheep for Maharashtra, India

Overseas Collaborating Countries:	India
Commissioned Organisation:	University of New England, School of Rural Science and Natural Resources, Australia
Project Leader:	Dr Stephen Walkden-Brown Phone: 02 6773 5152 Email: swalkden@metz.une.edu.au
Collaborating Institutions:	National Chemical Laboratory, India Nimbkar Agricultural Research Institute, India CSIRO Livestock Industries, Australia University of Melbourne, Australia
Project Budget:	$1,099,727
Project Duration:	01/01/1998 to 31/12/2002 (Project extended from 01/01/2001 to 31/12/2002)
ACIAR Research Program Manager:	Dr John Copland

Project background and objectives

Indian sheep in general have low fertility and, in 12 of the 15 agroclimatic regions of the country, their growth is limited by parasitic worms. The supply of sheep meat and skins cannot meet the national demand, and the cost of meat rises annually, while the shepherd families that farm the sheep live in poverty. Breeding programs that result in more lambs per ewe could vastly increase meat production in India, particularly if the offspring's resistance to diseases and parasites was strengthened too.

Parasitic worms interfere with a sheep's wool and meat growth, and make the animal weak, susceptible to other diseases and liable to die. For many years, farmers in Australia have dosed their sheep regularly with anthelmintic drugs to combat the helminth worms, but the worms are becoming immune and customers are beginning to object to chemicals in food and wool. Indian farmers cannot generally buy the expensive drugs.

The sheep initially selected for this project were the Deccani, Bannur and Garole breeds. Deccani sheep, a coarse-woolled meat breed, are the most common in Maharashtra. Bannur sheep produce hair and are considered to have a good body conformation for meat production. They yield more mutton per weight of carcass than other Indian meat sheep, while also being one of the better indigenous breeds.

Garole sheep come from the hot, humid, swampy Ganges delta and appear able to graze standing in water without getting footrot. These small sheep are the most prolific of the Indian breeds and may have contributed some ancestry to the Booroola Merino, whose first-cross ewes produce twice as many lambs per ewe mated as other Merino strains in Australia.

In the early stages of the project the Awassi breed, a fat-tailed sheep raised for meat, milk, and wool in the various countries of the Middle East, was also added to the breeding program.

To evaluate the efficiency of lamb production and parasite resistance of the Deccani and Bannur breeds, their reciprocal crosses and their crosses with the Garole and Awassi breeds with a view to subsequent development of a suitable composite meat sheep breed for Maharashtra. In Australia the scientists sought answers to the problem of worm resistance to anthelmintic medication

Project outcomes

The outcomes of this project have the potential to significantly alter sheep production in India. The breeding program yielded much useful information about the comparable reproductive performance

and gastrointestinal nematode (GIN) resistance of Deccani, Bannur, Awassi and Garole breeds. The scientists also detected superior genetic resistance to GIN infection in Garole crossbreeds.

New protocols and tests enabled quick and accurate identification of sheep carrying the prolificacy gene, using blood samples collected on FTA filter paper. The scientists determined the genetic basis of the prolificacy in Garole sheep and concluded that the gene was highly likely the same as that which led to high prolificacy in the Booroola Merino in Australia. Tests also indicated that the gene could be introduced into other breeds to increase prolificacy.

A study of four shepherds' flocks revealed significant subclinical production losses from uncontrolled GIN infection in Deccani sheep in semi-arid Maharashtra state. A hallmark of the project was the high degree of trust gained from the shepherds. This extended to the introduction into their flocks of rams carrying the prolificacy gene, where previously they had opposed introduction of any new breeds. Audio visual materials have been developed as teaching aids to extend the work among the shepherds.

In Australia a great deal was learnt about the relationship in Merino sheep between GIN, diet and dietary supplements. The scientists found that pastures enriched with legumes did not increase the resistance or resilience to infection to GIN in young sheep. They also learnt valuable information about the effect of drenching and nutritional supplementation on gaining repeatable egg counts from the sheep under study for worm resistance.

The project studies contributed considerable capacity building and at least four related research projects have now commenced. One of these is a large project to develop gene markers for worm resistance in sheep, to be undertaken by the University of New England in collaboration with the University of Melbourne, with funding from Australian Wool Innovation Pty Ltd. A second ACIAR project was also developed to consolidate, extend and take to fruition the findings of this project.

AS1/1997/069: The treatment of wool scouring effluents in Australia, China and India

Overseas Collaborating Countries:	China, India
Commissioned Organisation:	CSIRO Textile and Fibre Technology, Australia
Project Leader:	Dr Jock Christoe Phone: 03 5246 4000 Email: jock.christoe@csiro.au
Collaborating Institutions:	Ministry of Water Resources, China Ahmedabad Textile Industries Research Association, India Woolmark Company, Australia
Project Budget:	$933,045
Project Duration:	01/07/1999 to 31/12/2003 (Project extended from 01/07/2002 to 31/12/2003)
ACIAR Research Program Manager:	Dr John Copland

Project background and objectives

Wool scouring produces a discharge of wax, dirt, suint and pesticide that is highly polluting. The wool-scouring mills in China and India dump untreated discharge, which then pollutes waterways. CSIRO Geelong has developed ways to collect and treat the effluent and transform it into compost and potassium-rich fertiliser, and this project will fund research into treating and decontaminating effluents in China and India. The findings will help Chinese and Indian mill operators struggling to keep mills open and profitable in the face of new environmental regulations, and will also benefit Australian wool-scouring mills. The research will also help ensure that Australian greasy wool scoured after export to these two countries does not cause pollution.

Project outcomes

A training manual was produced to standardise procedures and methods of analysis between the collaborating research organisations in Australia, China and India. The training of key staff from China and India has been a successful transfer of knowledge that can be used for standardisation, monitoring, regulation and quality control purposes.

A series of comparative scouring trials showed that the removal of wool wax was similar for a range of Australian and Chinese wools. However, the levels of residual dirt were higher on the Chinese wools and they were much more yellow.

A major component of the project involved working with fourteen mills (four in India, six in China and four in Australia). They represented all segments of the industry from commission scourers, commission combers and vertical mills. The teams carried out process audits at each of the mills. These involved the scouring process itself, contaminant recovery and wastewater treatment. In addition two series of comparative processing trails were carried out in which the same wool was scoured at each of the participating mills before being made into top at CSIRO.

The mill audits have demonstrated that, in general, the quality of the scoured wool produced by the mills, especially those in China and India could be substantially improved. This is indicated by the poor processing performance of the scoured wool in terms of fibre wastage and fibre length in the top. In some cases comparatively small modifications to existing systems could have a strong impact on profitability.

Many Chinese and Indian scours are old and use old technology. They do not operate under equilibrium conditions so that they do not lend themselves to modernisation especially in relation to treatment of discharges. A major feature is the inefficient use of water. In modern scours counter-current flows enable the use of rinse waters in the scouring and suint bowls and the reclamation and

use of water from the scour effluent. Even with the use of modern scour designs the fine-tuning of them requires considerable expertise.

Generally the scours in China and India performed worse than the more modern scours in Australia in terms of resource usage (water and detergent), contaminant recovery (dirt and wool wax) and the extent of fibre entanglement.

The results have demonstrated outstanding prospects for significant improvements in both scouring and effluent treatment that will significantly reduce the cost of scouring and improve the quality of the scoured product. The efficiency of water usage can be increased and pollution of water courses greatly reduced for the benefit of communities where scours are located.

Many of the mills have changed their modes of operation as a result of the project. Another Chinese mill has scrapped its existing scouring lines and purchased more modern equipment from Australia. Another of the Chinese mills translated the entire ACIAR report into Chinese so that the staff could benefit from the study.

The cornerstone of CSIRO's approach to treating wool scouring effluents is a chemical flocculation process, Sirolan CF. A Sirolan CF pilot plant was operated at mills in Australia, India and China in order to demonstrate the effectiveness and simplicity of the technology under different operating conditions. The process performed well in all the trials. It removed virtually all of the wool wax and dirt from the effluents and more than 90 per cent of the organic load – the remaining organic matter coming from the water-soluble suint salts. As a result of these trials several of the mills have adopted the technology and several more have made enquiries about its installation.

AS1/1997/070: Development of specification and processing prediction techniques for the Chinese and Indian wool industries

Overseas Collaborating Countries:	China, India
Commissioned Organisation:	CSIRO Textile and Fibre Technology, Australia
Project Leader in Commissioned Organisation:	Dr Bill Humphries Phone: 03 5246 4000 Email: bill.humphries@tft.csiro.au
Collaborating Institutions:	China Textile University, China Northwest Institute of Textile Science and Technology, China Indian Woollen Mills Federation, India Cooperative Research Centre for Premium Quality Wool, Australia Woolmark Company, Australia
Project Budget:	$856,803
Project Duration:	01/07/1999 to 30/06/2003 (Project extended from 01/07/2002 to 30/06/2003)
ACIAR Research Program Manager:	Dr John Copland

Project background and objectives

China is the biggest importer of Australian raw wool and tops. India is a growing importer of Australian wool. The processing of wool in both countries provides considerable employment. China has a substantial domestic wool-growing industry, however, these wools suffer from poor growing conditions and thus have several undesirable qualities. The regions in which the wools are grown are economically deprived, and the local mills need better technology.

Quality is the main consideration in today's competitive textile industry. The way in which wool fibres influence spinning is the basis for defining wool quality, because spinning is the pivotal point in the processing of wool.

Woolgrowers in China and India had little incentive to improve their product because, unlike Australia, they received no price signals based on the processing performance of their wool. Growers would invest in producing better wool if they knew they would receive more for it. For this to happen, there needed to be objective measurements of the fibre characteristics that determine processing performance. This could then be the basis of price setting. It would improve the link between the raw wool supplier and the processor and provide the necessary market signals to improve the quality of the wool clip.

This project investigated the usefulness of primary objective measurements in clip preparation, wool-sorting and consignment building. Its main aim was to develop techniques - suitable for Chinese and Indian spinning mills - that used knowledge of fibre properties to predict yarn quality and spinning performance.

Project outcomes

In China the project made positive impacts on the quality of wool processing in the mills involved in the project through the adoption of the Yarnspec prediction model into mill quality control methodologies. This Australian-developed computer model was tested in both countries. This model can identify for a mill the modifications necessary to wool inputs and spinning machinery speeds and settings to achieve a certain quality of yarn. It enables alteration of mill settings so that cheaper wool top can be used without affecting quality and customer requirements are met. In addition, faster production reduces costs.

The audit of mill performances based on world's best practice has benchmarked quality control of individual mills and identified important areas where improvements can be made. The mills now understand the importance of wool characteristics and the relationship to yarn quality. Reports were

given to the review team of 10 per cent decrease in ends-down (that is, yarn breaks in spinning), 5 per cent improved spinning speed on pure wool and 8 per cent on wool/polyester blends, and the weaving efficiency ratio increased from 75 to 85 per cent.

At the International Wool Textile Conference a senior Chinese mill manager stated that the project has moved the Chinese wool textile industry from an 'experience-based system' to a 'scientific pre-known and pre-control system'. Several mills, as a result of the project, have purchased wool testing equipment from CSIRO and Europe.

In India the review highlighted excellent collaboration between the Australian and Indian partners. This was based on evidence of a good response and early success of the project in some of the participating textile mills. The experimental design of the project was highly commended by the review team. India is seen as a growing market for export, processing and onward selling of quality wool and wool blends to Europe and USA.

Overall, the project achieved the following progress and impacts:
Mills in India and China are now able to benchmark against global best practices and to compare their performance against others. A significant benefit has occurred from the quality testing audits from an accredited laboratory (CSIRO). Mills now recognize the large impact that top-dyeing processes have on yarn performance and understand the relationship between fibre properties and yarn quality. Finally, the Yarnspec computer model has been adapted to mills in India and China.

CS1/1995/129: High yielding anthracnose-resistant Stylosanthes for agricultural systems in India and China

Overseas Collaborating Countries:	Brazil, China, Colombia, India
Commissioned Organisation:	CSIRO Plant Industry, Australia
Project Leader in Commissioned Organisation:	Dr Sukumar Chakraborty Phone: 07 3214 2677 Email: Sukumar.Chakraborty@csiro.au
Collaborating Institutions:	Chinese Academy of Tropical Agricultural Science, China International Center for Tropical Agriculture, Colombia Indian Grasslands and Fodder Research Institute, India
Project Budget:	$897,222
Project Duration:	01/07/1998 to 31/12/2003 (Project extended from 01/07/2001 to 31/12/2003)
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

Stylosanthes is a fast-growing, tropical leguminous plant with various uses. In India it is the most important tropical legume for semi-arid and arid regions, mainly used in livestock production and in restoring soil fertility. In China it is mainly used as a green manure for soil enhancements, and in feed meal productions. Its nitrogen-fixing properties also help replenish soil nutrients in ley farming and intercropping systems. It also helps restore marginal lands with infertile acid soils and is important in revegetation programs.

Stylosanthes is also important in Central and South America, Africa and other Asian countries. The beef industry in northern Australia increasingly relies on *Stylosanthes* as a pasture plant for cattle. However, the major constraint to its use, wherever it is grown, is the fungus diseases anthracnose. The fungus is diverse and quick to adapt, and with growing international travel and trade the risk of even more damaging fungal strains entering Australia, India or China is increasing.

In this project Australia contributed its recognised experience in tropical pasture technology - its *Stylosanthes* expertise in particular - to help combat the anthracnose disease problem.

The aim of the project was to select strains of *Stylosanthes* resistant to anthracnose, with the ultimate intention of providing high-yielding, disease-resistant varieties of *Stylosanthes* that perform better on the farms of India, China and northern Australia.

Project outcomes

The project made excellent progress against all objectives. There was extensive screening of lines from all partners and many showed excellent resistance. The project contributed to the release of two cultivars of *Stylosanthes seabrana* for Maharashtra in India, two *S. guianensis* cultivars named Reyan7 and Reyan10 in China, and one *S. capitata-S. macrocephala* multiline cultivar 'Estilosantes Campo Grande' in Brazil. Quantitative traits loci (QTLs) for resistance were mapped and several are available as markers. Studies of anthracnose epidemiology and risk mapping have given, for the first time, a clear understanding of the genetic structure and virulence of the *C. gloeosporioides* population in all participating countries.

Good information has been collected on the current state and future potential for commercial leaf meal and seed production in India. Leaf meal production is being largely undertaken by smallholder farmers who interact with large poultry producers through farmer cooperatives. This is being supported by a vigorous stylo seed production sector of smallholder farmers growing high-yielding

anthracnose-resistant varieties developed in this project. The gradual replacement of existing cultivars with high-yielding and resistant varieties for the cropping, horticulture and wasteland development sectors will mainly be demand-driven, as benefits of growing the new varieties become apparent through ongoing demonstrations by government and NGOs.

Early indications of farmer-level impacts are available from the 'Surashettykopa' cluster of villages near Dharwad in India. BAIF, a local NGO, started participatory work in 1998 on stylo and other forage seed production and selected farmers were given hands-on training at research farms, where they received seeds and other inputs. The initial figure of eight farmers producing *S. hamata* and *S. scabra* seeds in the first year has increased to >115 farmers in 5 years. According to BAIF, the benefits to smallholder farmers (<2 ha) from growing stylo as a component of the whole-farm improvement program has been exceptional. Other indications of impact come from the gradual replacement in commercial seed production of the susceptible cultivar Fitzroy by the highly productive and resistant *S. seabrana* accessions promoted by the project. Many other stylo cultivars will be released as a result of project research in partner countries.

The project established a stylo web site: www.csiro.au/stylointernational. Project experiences and findings are also described in an ACIAR publication entitled 'High-yielding Anthracnose-resistant *Stylosanthes* for Agricultural Systems'.

The broad testing of extensive *Stylosanthes* germplasm in 20 sites across the world, the release of several Brazilian and Chinese cultivars, the knowledge gained on the nature of pathogen populations in India, Brazil and Australia, and the novel information on the anthracnose disease threats to Australia from China and India, are all examples of sound scientific achievements and outputs. It has expanded the scientific base considerably for continued and targeted improvement in anthracnose resistance in *Stylosanthes* in China, India and Brazil, and this will greatly assist the livestock industries of these countries.

CS1/1996/013: Herbicide-resistant weeds of wheat in India and Australia: Integrated management

Overseas Collaborating Countries:	India
Commissioned Organisation:	University of Adelaide, Department of Agronomy and Farming Systems, Australia
Project Leader:	Dr Gurjeet Gill Phone: 08 8303 7744 Email: gurjeet.gill@adelaide.edu.au
Collaborating Institutions:	CCS Haryana Agricultural University, India Punjab Agricultural University, India
Project Budget:	$420,090
Project Duration:	01/01/1998 to 30/06/2003 (Project extended from 01/07/2001 to 30/06/2003)
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

The 'Green Revolution' saw large increases in wheat yields in India. Rotations of rice and wheat crops became popular in areas with good soil fertility and assured irrigation. But within a few years of starting rice cultivation, populations of the grass *Phalaris minor* started to increase and threatened wheat production in these areas. *Phalaris* is a prolific seed-producer and, in the absence of control, densities in the field can quickly reach 2000 plants/m^2, when it will out-compete wheat.

Therefore, in 1978 India turned to the herbicide isoproturon to control this troublesome weed. The chemical worked effectively for about 15 years and proved popular with farmers. However, in 1993 the first instance of resistance to isoproturon in *Phalaris minor* was confirmed and since then there has been a rapid expansion in the area affected by resistant weeds.

With continuing growth in the human population and little scope for using more land in agriculture, there was an urgent need to develop an integrated weed management package to combat this problem. The sustainability of the rice-wheat system – valued for its profitability and its provision of staple foodstuffs – was threatened.

This project aimed to study and counter the deleterious effects of herbicide resistance in the grass plant *phalaris* in wheat fields in northern India and Australia. Through studies of a range of both chemical and non-chemical strategies for weed control the research team sought to develop cost-effective and environmentally sound *phalaris* management.

Project outcomes

The reviewers considered that the project team had delivered on all of its stated objectives, and would contribute financial, productivity and sustainability benefits to the rice-wheat systems of India. The outcomes had been achieved by a combination of imaginative research, strong farmer participation, and confirmation of an early solution to the widespread and devastating problem of herbicide resistance in *Phalaris minor*. Farmers saw yields that had declined to about 2 t/ha return to about 4-5 t/ha with the correct identification of resistance to isoproturon (IPU), the testing and release of three new chemicals (fenoxaprop, clodinafop, sulfosulfuron) for the control of *P. minor*, and through opportunities to reduce *P. minor* establishment and save costs with zero-till. The project was well supported by strong weed research teams and the resources of the key institutions CCS Haryana Agricultural University (Hisar), Punjab Agricultural University (Ludhiana) and the University of Adelaide (Roseworthy).

CIMMYT introduced zero-till technologies around 1980 but there was little farmer adoption until the mid-1990s, when *P. minor* became an unmanageable problem with traditional technologies. This project showed that zero-tillage is a key to *phalaris* management and helped to stimulate the uptake, with zero-till wheat areas in Haryana going from nil in 1997-98 to 20,000 acres in 1999-2000 and 100,000 acres in 2000-2001, whilst in Punjab the area grew to 10,000 ha in 2000. Increased farmer

interest and demand promoted considerable development of local manufacture of zero-till seeders between 1996 and 2001. With experience, farmers rapidly identified that fuel savings could offset the increased cost of new herbicide controls where the need still remained.

Australian scientists investigated the physiological and genetic basis of wheat competitiveness. They found that capacity to maintain yield was associated with crop height and length of the first leaf (vigour), and that there were key characteristics that identified varieties capable of suppressing weeds. A study of Australian varieties released between 1860 and 1994 showed that this set of competitive characteristics had not changed.

The project was extended to 2004 to capitalise on very positive scientific benefits, strong initial farmer uptake of technologies, and strong economic impacts. Research would also focus on rice crops in the rice-wheat rotation.

CS1/1997/114: More efficient breeding of drought resistant peanuts in India and Australia

Overseas Collaborating Countries:	India
Commissioned Organisation:	Queensland Department of Primary Industries, Australia
Project Leader:	Dr Graeme Wright Phone: 07 4160 0734 Email: graeme.wright@dpi.qld.gov.au
Collaborating Institutions:	Indian Council of Agricultural Research, National Research Centre for Groundnut, India International Crops Research Institute for the Semi-Arid Tropics, Agronomy Division, India
Project Budget:	$551,423
Project Duration:	01/07/1998 to 31/12/2003 (Project extended from 01/07/2001 to 31/12/2003)
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

Peanut is one of the most drought-tolerant of all grain legumes, and is therefore grown in many of the world's semi-arid cropping regions. It is a particularly important crop in India, which is the world's largest producer. In Australia, most of the crop is grown in Queensland; its production and market potential are expanding.

The Indian crop is mainly grown under rainfed conditions, which means that production is inherently variable. The final yield of the plant is greatly affected by lack of available water during the growth phase. In Australia, this can also be a problem. In both countries the situation is exacerbated by high evaporation rates and the low water-holding capacity of the soils on which much of the growth takes place.

So a high-yielding cultivar that continues to produce well under drought conditions is a priority to enable stability of production. That is why much research for the last decade has attempted to improve performance by selecting plants with good pod yield. As well as spending time trying out plants in large-scale trials under different conditions, a study of plant physiology has revealed which features of the plant correlate best with drought tolerance. A previous ACIAR project (CS1/1992/016) identified three significant physiological features of drought-tolerance (amount of water transpired (T), water-use efficiency (W) and harvest index (HI)) that correlated strongly with pod yield. The traits can be assessed and selected for with relative ease on a large number of plant lines.

This project was designed to test whether using the trait approach (indirect selection) could improve the efficiency of selection. In other words, would physiological traits be more effective and efficient indicators than direct selection for pod yield alone?

Project outcomes

Reviewers found that research had met the project objectives. However, additional data analysis was required to fully extract valuable information from the project results, for the benefit of peanut breeding and research activities in both countries. Highlights of achievements are summarised below.

The first objective was to develop more efficient screens and selection methods for yield component traits through better physiological understanding, giving special attention to the SPAD-chlorophyll meter. Researchers found that SPAD-chlorophyll meter readings (SCMR) in both glasshouse and field were a good means of measuring water-use efficiency, and correlated closely with other means of measuring W and previously identified surrogates of W (specific leaf area SLA and specific leaf nitrogen SLN).

The second objective was to make crosses involving parents selected for high water-use efficiency (W), water transpired and harvest index, as well as combining these in the backgrounds of locally adapted varieties; also to evaluate and validate the use of physiological selection traits to achieve superior yield performance in appropriate target environments in India and Australia.

Bi-parental crosses were made amongst the parents with the special traits, then crosses were made between these and locally adapted varieties in the four Indian breeding centres and in the Australian breeding program. Researchers found that overall there was no difference between empirical and physiological trait-based selection in development of higher yielding genotypes in either India or Australia. However trait-based selection retained high-yielding progeny that also had higher transpiration efficiency – that is, trait-based selection retained useful genotypes that would have been discarded with conventional empirical selection.

In India, progeny were developed that produced significantly higher yields than locally adapted varieties in each of the country's main peanut-growing regions, in both rainy (rain-fed) and post-rainy (irrigated) seasons.

In Australia, some short-season progeny were identified with very low aflatoxin levels in drought environments and other progeny with high blanchability (a desirable quality attribute).

The third objective was to undertake a quantitative assessment of the cost-benefit of using indirect selection methods compared to conventional yield selection approaches for the identification of drought-resistant peanut cultivars. Even though costs of the trait method were much higher than those for the conventional method, cost-benefit analysis showed there would be significant economic benefits from trait selection even if its yield advantage was quite small. Similarly improved cultivars, with a 19.6 per cent yield advantage, would have a significant economic benefit over local cultivars in India. These conclusions, however, are based on an optimistic assumption of a 25 per cent adoption rate for a new variety over the whole Indian area sown to peanuts.

CS2/1994/050: Management of white grubs in peanut cropping systems in Asia and Australia

Overseas Collaborating Countries:	India
Commissioned Organisation:	Queensland Department of Primary Industries, Australia
Project Leader:	Dr John Rogers
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Collaborating Institutions:	International Crops Research Institute for the Semi-Arid Tropics, India
	Rajasthan Agricultural University, India
	University of Queensland, Australia
Project Budget:	$1,039,796
Project Duration:	01/07/1997 to 31/10/2002 (Project extended from 01/07/2001 to 31/10/2002)
ACIAR Research Program Manager:	Dr TK Lim

Project background and objectives

Peanuts (also referred to as groundnuts) are a major crop in many areas of the tropics and semi-tropics. They rank in the top 10 of the world's most important food crops and are particularly important in India, where they are a major source of cooking oil and protein. About 14 million families farm 8.6 million ha of peanuts in India, but it is estimated that the crop may influence the livelihood of more than 100 million people in the country.

However, white grubs, which are soil-dwelling larvae of scarab beetles, feed on the roots of the peanut plant, killing seedlings and sometimes older plants as well as reducing drought tolerance and thereby affecting final yields. The grubs can also attack other important plants such as sugar cane and millet. In India, the value of the peanut crop lost to white grub attack is estimated to be about $800 million per year, while Australia suffers losses of at least $1 million per year. All of Queensland's current and potential peanut-producing areas have endemic populations of white grub species.

Peanuts are often grown in rotation with other crops, especially cereals. While these other crops are often less susceptible to damage from white grub attack they may contribute to the maintenance of grub populations that subsequently devastate the peanut crop. Many Indian farmers attempt to control the grubs by applying undesirable and toxic insecticides to enable them to grow peanuts.

This project sought to develop a better understanding of the white grub in the peanut-growing areas of India and Australia. The research investigated the ecology and behaviour of larvae and adults, the distribution of species, and the relationship between crop yield and pest density, and tested ways to control the pest.

Project outcomes

In southern India the data obtained during the project in southern India established the basis for an environmentally friendly and economically-viable pest-management system for white grubs on groundnut in southern India. Researchers found that *Holotrichia spp*. were the main white grub species associated with groundnuts in Andhra Pradesh, Karnataka and Tamil Nadu. *H. reynaudi* predominated in the central Deccan area, while *H. serrata* was most abundant in areas to the south and west. A new, undescribed *Holotrichia* species near *H. consanguinea* occurred in mixed populations with *H. reynaudi* but its full distribution remains uncertain. White grub densities correlated closely with percentage of damaged groundnut plants on farms and grub densities were found to persist from year to year. The preferred host trees for *Holotrichia* adults in southern India were identified, and this will assist grower-initiated surveys of pest occurrence there.

Chlorpyrifos and imidacloprid insecticides were tested and found effective under specific conditions against *H. serrata* and *H. reynaudi*. Farmer surveys in Andhra Pradesh (AP) indicated use of

insecticides for white grub control in 37.5 per cent of farms sampled, but none used for this purpose in Karnataka and Tamil Nadu.

In northern India the experimental program has advanced the understanding of the pest and its damage, especially in relation to the use of insect pathogens and plant-derived adult attractants. These advances supplement the existing chemical control programs. The physiological effects of root-cutting and actual white grub damage were found to mirror the effects of water stress on the groundnut plant.

Groundnut is the most preferred monsoon crop in Rajasthan. This means that white grub populations in intercropped situations can be controlled by treatment of only the groundnut seed. Larvae of *H. consanguinea* were found to move freely in their endemic sandy soils in search of food and to prefer soil moisture content of 40-60 per cent. Knowing this helped scientists determine optimum placement for inoculum of the insect pathogen *Metarhizium anisopliae*.

Laboratory and field bioassay of leaf extract from host trees of *H. consanguinea* showed neem and khejari were the best sources of plant attractant (kairomone) for *H. consanguinea*, and green leaf volatiles from neem attracted more beetles than khejri. The field evaluation of the kairomone compound has been undertaken for one year and the results are encouraging.

Data obtained in Australia established the status of *Heteronyx piceus* as a peanut pest, and created the basis for a pest-management system for dryland peanut production in the South Burnett region of Queensland. Insecticide treatment targeting young larvae in peanuts is the chemical control option with the greatest likelihood of success.

Surveys of white grubs in southeast Queensland peanut fields found that the abundance of white grubs was similar to that recorded up to 20 years previously, i.e. peanut white grubs are a persistent rather than transient problem. Landscape position is a key risk factor; economically damaging *H. piceus* populations are much more likely to be encountered on the upper parts of the landscape than in the lower half. Double-cropping with peanuts also increased infestation risk.

LWR/1998/017: Integrative technologies for assessing the extent and cause of degradation in arid community rangelands

Overseas Collaborating Countries:	India
Commissioned Organisation:	CSIRO Sustainable Ecosystems, Australia
Project Leader:	Dr Margaret Friedel Phone: 08 8950 7140 Email: Margaret.Friedel@csiro.au
Collaborating Institutions:	Central Arid Zone Research Institute, India
Project Budget:	$372,807
Project Duration:	01/07/2000 to 30/06/2004 (Project extended from 01/01/2004 to 30/06/2004)
ACIAR Research Program Manager:	Dr Ian Willett

Project background and objectives

Scientists and policy makers are aware of the serious degradation or desertification of grazing lands in semi-arid/arid regions throughout the world. However clear indications that this is occurring are often only clear after degradation is well underway and either impossible or uneconomic to repair.

Similarly land users often find it difficult to detect the effects of degradation before productivity loss is very significant. This is largely due to the extreme variability of productivity year to year resulting from rainfall variability; that is, the 'noise' associated with seasonal conditions masks the decreasing trend in productivity associated with degradation. This project should enable better discrimination between these two causes of variability in production, leading to more effective diagnosis of desertification. Use of remote sensing will allow this to be achieved economically in extensive areas of low productive potential.

This project aims to apply and adapt Australian-developed techniques for assessing land degradation to the Indian desert environment, using remotely-sensed data; to gather ground-based survey data on socio-economic factors, the natural resource base and animal production for interpreting the results of remotely sensed analyses; to develop means of information exchange with village communities in order to explain land degradation; and to develop capacity with Indian colleagues for their independent use of all methodologies.

Project outcomes

The development of remote sensing applications allowed a clearer picture of degradation of land in Indian conditions to emerge. A robust index of vegetation cover was developed to allow the responses of vegetation to rainfall, and degradation, to be determined. Satellite data was used in this development. A Geographic Information System (GIS) was established for trial in the Jodhpur region. This incorporated a range of information including the vegetation cover index, land use, infrastructure and resilience of vegetation to degradation (measured by vegetative responses in the 2001 and 2003 seasons). Livestock, social and economic data from four villages were also included. As a result a series of interpretative tools to determine the extent of human impacts on common grazing lands were generated.

Working with villagers facilitated collection and analysis of data to verify remote sensing developments on-the-ground. Data collected from 100 households was incorporated into the GIS to give a clearer picture of how the remotely sensed and ground assessed degradation patterns correlated but no causal relationships were suggested. Working with local Block Development Officers products were tested with community farmers to explain technical remote sensing outputs, though the level of complexity suggested another target group be approached. Connections were built with administrators and policy makers initially through workshops presenting the remote sensing tools.

The potential to implement these tools in programs of agencies working in land management was endorsed. Capacity building at CAZRI will be a key to further dissemination and following up on this endorsement. A fully equipped image processing facility was established at CAZRI with training of

Indian scientists in a range of remote sensing and ground mapping techniques. CAZRI, the Ministry of Environment and Forestry's national grassland mapping activities and an NGO, Maru Gochar Yojna involved in community development programs, are all applying new ground sampling techniques introduced through the project.

Participating villagers have also benefited, after receiving veterinary advice and prescriptions and saplings of forage species, offered by the project team as a means of building trust.

LWR2/1996/215: Capturing the benefits of seasonal climate forecasts in agricultural management

Overseas Collaborating Countries:	India, Indonesia, Zimbabwe
Commissioned Organisation:	Queensland Department of Primary Industries, Australia
Project Leader:	Dr Jeff Clewett
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Collaborating Institutions:	Agency for Agricultural Research and Development, Indonesia
	Badan Meteorologi dan Geofisika, Indonesia
	University of Mataram, Indonesia
	Tamil Nadu Agricultural University, India
	Matopos Research Station, Zimbabwe
	Zimbabwe Meteorological Services, Zimbabwe
	Bureau of Meteorology, Australia
	Queensland Department of Natural Resources, Australia
	University of Western Sydney, Australia
Project Budget:	$982,927
Project Duration:	01/01/1999 to 31/12/2002 (Project extended from 01/01/2002 to 31/12/2002)
ACIAR Research Program Manager:	Dr Tony Fischer

Project background and objectives

Climate variability has a huge effect on agricultural production and the general well-being of communities across the world. An understanding of variability is particularly important in those countries (Australia, Indonesia, India and parts of Africa) affected by the El Nino/Southern Oscillation (ENSO) phenomenon, because ENSO can cause large swings in rainfall. The severe droughts associated with one phase of the cycle can bring extensive fires, crop losses and famine.

Generalised rainfall prediction several months in advance has long been possible by analysing sea surface temperatures and air pressure differences in key locations around the world. On top of this, considerable progress has been made in the last decade in understanding the atmospheric and oceanic processes causing ENSO and its periodic manifestations of drought, and this knowledge is now used to make more accurate seasonal climate forecasts.

Timely knowledge of upcoming climatic conditions can greatly benefit farmers and land managers, especially in areas where rainfall is inherently variable and unreliable. However, detail of the forecasts does not often translate into action by farmers and other key resource managers. This project sought to capture the benefits of the new, detailed climate forecasts and thus improve agricultural management in ENSO-affected areas.

Project outcomes

The project showed that translating relatively recent ENSO knowledge into useful information for managing risks and opportunities associated with climate variability is a challenge for traditional agricultural research and extension. Researchers improved the skill and value of forecasting, increased the lead time for prediction, identified the key decisions and practices in the farming cycle to which forecast information may be applied, and communicated information in a risk-management context.

The project made important contributions to increasing the understanding of ENSO in Indonesia, where the impact is as great as anywhere in the world. A key finding was that the changing seasonal pattern of spatial coherence of rainfall correlated with predictions.

The development of an international RAINMAN version led to excellent progress in assembling a global database of monthly rainfall and some other data sets. Outputs for India and Zimbabwe have significantly increased understanding, particularly through use of simulation models to show amplified impacts on agricultural systems compared with ENSO impacts on seasonal rainfall.

A highlight was the successful calibration and validation of the GRASP pasture simulation model for Zimbabwe pastures. And in Tamil Nadu, India, scientists have assessed seasonal climate forecasts through farm surveys and workshops, and undertaken analyses using crop simulation models.

The project outcomes should lead to changes in farm management decisions, to better adapt farming to climate variability, and to prepare for climate change.

LWR2/1998/136: Survey of potential of manure for meeting crop nutrient needs with integrated nutrient management in Madhya Pradesh, India

Overseas Collaborating Countries:	India
Commissioned Organisation:	Queensland Department of Natural Resources, Resource Sciences Centre, Australia
Project Leader:	Dr Ram Dalal Phone: 07 3896 9895 Email: Ram.Dalal@dnr.qld.gov.au
Collaborating Institutions:	Indian Institute of Soil Science, India Queensland Department of Primary Industries, Australia
Project Budget:	$150,000
Project Duration:	01/01/2001 to 31/03/2003 (Project extended from 01/07/2002 to 31/03/2003)
ACIAR Research Program Manager:	Dr Tony Fischer

Project background and objectives

Concerns for organic farming and increased use of organic manures are being raised in the India. Despite low fertility status of soils in Madhya Pradesh, less than 50 per cent of dung produced is used as farmyard manure (FYM), i.e. for growing food crops. It is necessary to assess the potential of FYM and hence increasing its use to meet crop nutrient needs. This requires consideration of factors affecting competing uses of FYM, now and into the future, as well as consideration of alternative nutrient sources.

Following discussions in India and Australia it was decided to initiate a small project in which the soil fertility and manure management practices and attitudes of typical farming villages in Madhya Pradesh were thoroughly surveyed through physical sampling and interview. A parallel effort would be conducted in and around the feedlots of the Darling Downs in Queensland.

The specific objective would be to learn of the constraints – real, perceived, biophysical and economic – to the better use of manure as a source of nutrients for cropping. Such information would underpin future research on manure utilisation as a fertiliser substitute. The focus would be on winter and summer cropping on vertisols, the predominant cropping system and soil type at each location.

Project outcomes

The researchers found that both the Indian and the Australian FYM users believed that FYM was good for increasing yield, and most felt that it increased water-holding capacity of soil. However, the knowledge about the plant nutrient value of FYM among the users was very low. Consequently Indian farmers under-fertilised, whereas the Australian farmers over-fertilised, their crops, meaning both miss the realisation of optimum gross margins. Moreover, the Australian farmers also faced the potential pollution of dams and waterways. Researchers found that in the Indian conditions FYM was composted with crop residue and household waste, and hence was low in nitrogen, phosphorus and potassium but high in carbon/nitrogen ratio. By contrast in Australia FYM was high in nitrogen, phosphorus and potassium (especially phosphorus) and low in carbon/nitrogen ratio.

There was an urgent need to understand the nutrient-release characteristics of different FYMs and their effects beyond the first year of application. FYM use in an integrated nutrient management (INM) system needed to be better understood so as to evaluate the manure management practices, application rates, types of complementary fertiliser and costs of various nutrient inputs in relation to the cropping systems. Such information needed developing for use in a participatory approach involving farmers and lot-feeders, directed especially towards those identified as the most effective users of FYM and new technology.

The project created awareness of FYM use among landholders both in India and Australia. In both countries, landholders on vertisol soils would prefer to use FYM to increase productivity and attain economic and environmental sustainability in an INM system.

India: multilateral

ASEM/1998/081: Global Mountain Program on: Investigating issues and options for managing sustainable livelihoods on marginal mountain farms

Overseas Collaborating Countries:	Bhutan, India, Nepal
Commissioned Organisation:	International Centre for Integrated Mountain Development, Nepal
Project Leader:	Dr Pradeep M Tulachan
Collaborating Institutions:	Ministry of Agriculture, Bhutan
	Council for Advancement of People's Action and Rural Technology, India
	GBP Institute of Himalayan Environment and Development, India
	Himachal Pradesh Agricultural University, India
	National Centre for Agricultural Economics and Policy Research, India
	Centre for Resource and Environmental Studies, Nepal
	Winrock International, Nepal
Project Budget:	$447,120
Project Duration:	01/07/1999 to 30/09/2002 (Project extended from 01/07/2002 to 30/09/2002)
ACIAR Research Program Manager:	Dr Ken Menz

Project background and objectives

Between landless and large land holders there are intermediate groups—comprising of the majority of mountain farmers (>60 per cent)—which can be classified as marginal. Under the CGIAR Systemwide Global Mountain Programme, convened by the International Potato Centre (CIP), this project focused on the study of livelihood management strategies for marginal farms under four different agricultural systems: high mountain livestock dominated farming (Bhutan); crop-livestock mixed subsistence farming in mid hills (Nepal); swidden farmers (Northeast India), and horticulture farming (Himachal Pradesh, India).

The project global objective was to better understand the issues and options of sustainability and un-sustainability of agriculture and livelihoods on marginal farms in the Hindu-Kush Himalayas (HKH). Thus researchers undertook studies of four farming systems/locations with specific objectives for each:

- Bhutan, the impact of changing patterns in livestock management on livelihoods of marginal farmers, and status of natural resources and agricultural land
- north east Indian Himalaya, experiences in promoting alternative land-use systems in shifting cultivation areas, to improve livelihoods and ecological stability
- Himachal Pradesh, India, to assess sustainability of newly introduced crops and practices and increase income from marginal farmlands (horticulture, vegetables, floriculture etc.)
- Nepal, to assess the impact of accessibility (to goods and market services) on the structure and dynamics of marginal farms in different mountain farming systems.

Project outcomes

The researchers grouped major issues for each region under three headings: socio-economic, technological and policy related issues.

In Bhutan they found the major socio-economic issues were: low levels of livestock production; low income; food insecurity; support services for nomadic pastoralists; out-migration and farm labour scarcity; low literacy; land shortage, and shortage of fodder. Technological issues were: poor quality and composition of livestock; lack of technological awareness, and skills and inadequate know-how on computation and utilisation of local feed resources. Policy issues were: no clear-cut policy on land-tenure regulations; horizontal and vertical integration of livestock development missing; no clear policy on sustainable rangeland farming systems, and lack of a legal framework with respect to pasture damage by stray animals.

In Himachal Pradesh, India the socio-economic issues were: food insecurity; poverty; scarcity of farm labour; lack of available credit; unreliable and poor quality of agriculture inputs; inadequate markets for bumper harvests; large number of intermediaries in the market; poor infrastructure, and limited participation of women in decision-making. Technological issues were: inadequate infrastructural development; poor delivery of extension services; unorganized dissemination of market information, and declining soil fertility. Policy issues were: poor institutional support to farmers (accessibility of inputs, services, subsidies and empowerment).

In Northeast India socioeconomic issues were: shifting cultivation (Jhum) and reduced Jhum cycle; land fragmentation; out-migration resulting in farm labour scarcity; inadequate opportunities for income generation, and distant location of villages resulting in inaccessibility to inputs extension services and credit facilities. Technological issues were: inadequate technology flow, and poor capability of farmers to absorb new knowledge. Policy issues were: flaws in policy framing and implementation; inappropriate attitude of policy personnel, and government ignoring specific regional needs.

In Nepal socioeconomic issues were: food insecurity; extension efforts favoured larger farms; poor accessibility to inputs; services and markets; land fragmentation; small land holdings, and a lack of empowerment to marginal farmers. Technological issues were: poor adoption of technologies; inadequate uptake of niche potentials, and soil fertility/erosion. Policy issues were: non-existence of policies and guidelines for marginal farmers; lack of prioritisation and effective implementation for R&D; need for empowerment of both male and female marginal farmers, and protection of their interests.

In essence the key issues for all regions were:

- food security and poverty arising as a result of intrinsic factors such as small farm land holdings
- out-migration and lack of entrepreneurship
- extrinsic factors such as poor extension support and services, poor market linkages and inaccessibility to appropriate options.

The absence of policy and local capacity to empower farmers in their local resource planning and management are also important contributing factors to their marginalisation.

CIM/2000/066: Host resistance, epidemiology and integrated management of faba bean, chickpea and lentil diseases

Overseas Collaborating Countries:	Bangladesh, China, Egypt, Ethiopia, India, Iran, Morocco, Nepal, Pakistan, Syria, Turkey
Commissioned Organisation:	International Center for Agricultural Research in the Dry Areas, Syria
Project Leader:	Dr Amor Yahyaoui Phone: + 963 21 221 3433 Email: a.yahyaoui@cgiar.org
Collaborating Institutions:	Agriculture Victoria, Australia Department of Agriculture, Western Australia, Australia NSW Agriculture, Australia University of Adelaide, Australia
Project Budget:	$444,320
Project Duration:	01/07/2001 to 30/06/2004
ACIAR Research Program Manager:	Dr Colin Piggin

Project background and objectives

ACIAR has already supported research to build up the collection of the pulses faba bean, lentil and chickpea germplasm at ICARDA and to develop disease resistance in lentil and faba bean. This project focused on pulse diseases through collaboration between ICARDA and Australian research institutions. Specific scientific objectives were to study the epidemiology of major diseases affecting cool-season food legumes in West Asia and North Africa (WANA), particularly those caused by *Ascochyta fabae, A. rabiei, Fusarium oxysporum f.sp. ciceris* and *lentis*, *Botrytis fabae* and *Uromyces viceae-fabae.* The studies aimed to provide missing critical information on factors affecting the distribution, development and spread of these diseases. Scientists worked to determine variability in virulence of pathogen populations on a range of host genotypes and evaluate germplasm and breeding lines of faba bean, chickpea and lentil originating from the ICARDA/Australia project for disease resistance and adaptation. They also initiated the development of computer-based simulation models of epidemics to enable disease forecasting and to use as decision-support tools for disease management (e.g. fungicide application).

Project outcomes

The results reported are the outcomes of close collaboration and partnership between the commissioned and collaborating institutions. Major outputs from the project include:

- understanding of the genetics of resistance of faba bean Ascochyta blight
- developing improved methods for disease resistance screening and adopting them in the breeding program to increase the efficiency of screening for disease resistance
- identification and selection of faba bean with resistance to chocolate spot, Ascochyta blight, rust and root rot
- identification and selection of lentil lines with resistance to Ascochyta blight and Botrytis grey mould. These activities will continue in the newly approved ACIAR project
- new chickpea lines with resistance to Ascochyta blight
- epidemiological studies and development of integrated disease management for chickpea Ascochyta blight
- identification of new sources of resistance, pre-emptive screening of Australian material to exotic diseases not yet encountered in Australia.

The project achieved good results at both the practical and scientific levels. New chickpea lines were released in 2004 and others will be released in 2005.

Information gathered from works on epidemiology of diseases revealed that the sexual stage of the pathogen causing Ascochyta blights of chickpea and lentil is formed on the relevant crop's stubble, left from previous season, upon exposure to cold (less than 10C) moist conditions. The winter chilling requirement for the fungi suggests that these diseases will occur earlier following cooler autumn conditions. Thus, timing of the first spray should be advanced in years when autumn conditions are colder. Furthermore, the results highlighted the importance and the need for proper crop hygiene and rotation, even in years that are not favourable for disease development.

Enough information on disease epidemiology and the effect of different environmental conditions (Temperature and rainfall) permitted the development of computer simulations that will help in designing the control strategies for Ascochyta blights infecting different pulses. Sources of resistance to major diseases affecting pulses were identified and their resistance confirmed both at ICARDA and Australia Seeds of these lines were multiplied, shared with the Australian breeding programs and are ready to be distributed to national breeding programs in the region. Combined resistances to Ascochyta blight, chocolate spot, Cercospora leaf spot and certain viruses in faba bean and to Ascochyta blight and vascular wilt in chickpea has also been identified

Collaborative efforts between partners enabled the combination of resistance genes from various sources to develop lines with high level of resistance to chocolate spot and Ascochyta blight of faba bean. This is witnessed by the high performance of new lines, even under high disease pressure. Some of these lines have already been released (Farah) and others will be released soon. This will also result in reduced reliance on chemical application.

The project ensured the exposure of Australian varieties and advanced lines to potential pathogen diversity, as well as to diseases not yet encountered in Australia but that might be of major threat to chickpea and lentil industry in the future. Results indicated the necessity to deploy more efforts in incorporating wilt resistance into Australian chickpea lines. As for lentils, good level of resistance was already found in some of the Australian commercial lines and this will be given priority for future commercialization based upon good levels of resistance observed in the field.

The application of IDM package to control chickpea Ascochyta blight in farmers' fields, with their participation was demonstrated through the organization of two field days in Syria to demonstrate the benefit of the package. It is hoped that the package developed will be picked up by different national programs in the region. The improved resistance of the new Kabuli lines, expected to be released in 2004 and 2005 was evident in the yields achieved under disease situations. The prospect is that Ascochyta management packages for these varieties, in the absence of external sources of reinfection, will involve only two strategically timed applications.

At the scientific level, results from works on epidemiology of diseases indicated that subculturing of pathogens through a number of generations should be kept to minimum to maintain high inoculum aggressiveness for all disease resistance screening. As there was no significant effect of the age of the plant, nor was there an interaction between age of plants and genotypes, on faba bean Ascochyta disease development, seedlings can be inoculated at a young age for disease resistance testing.

Study on genetic of resistance to faba bean Ascochyta blight permitted the Identification of alternative Ascochyta blight resistant genes to the one in Ascot. This is expected to enable diversification of the resistance genes used in the Australian breeding program. The identification of the most aggressive isolates of faba bean Ascochyta blight and chocolate spot causing fungi at Adelaide and ICARDA will enable selection for a high level of resistance in glasshouse disease screening undertaken at both institutions. Results revealed that there is a low risk of seed transmission for all but the most sensitive varieties, and indicate the necessity for using seed dressing fungicides and foliar sprays to protect these varieties.

PHT/2000/080: Selection for peanut varieties with low aflatoxin risk

Overseas Collaborating Countries:	India
Commissioned Organisation:	International Crops Research Institute for the Semi Arid Tropics, Genetic Resources and Enhancement Program, India
Project Leader:	Dr S N Nigam Phone: + 91 40 329 6161 Email: s.nigam@cgiar.org
Collaborating Institutions:	Acharya N.G. Ranga Agricultural University, India Queensland Department of Primary Industries and Fisheries, Australia
Project Budget:	$396,458
Project Duration:	01/07/2001 to 30/06/2004
ACIAR Research Program Manager:	Dr Greg Johnson

Project background and objectives

Peanuts are a multiuse crop, providing protein for humans and animals, cooking oils and income. Aflatoxin contamination of peanuts, caused by the soil fungi *Aspergillus flavus* and *A. parasiticus*, affects both people and animals. It is particularly prevalent under end of season drought conditions, common in many parts of India Management techniques to reduce aflatoxin contamination risks have been developed but are difficult and costly for resource-poor farmers to implement.

The project has worked to identify peanut germplasm with low aflatoxin risk, a far more viable means of helping smallholders manage aflatoxin risk. The initial work focused on identifying varieties that demonstrate low aflatoxin risk and determining the mechanisms responsible for this low level of risk. By identifying and assembling a set of selection tools an index of genotypes with low-aflatoxin risk traits may be possible.

The research built on the existing knowledge base for aflatoxin problems. There is no information on the reaction of wild *Arachis*-derivatives to infection by *A. flavus* and subsequent aflatoxin production. Portable rainout shelters (developed in earlier research), growth cabinets and recently developed *A. flavus* sick plots at ICRISAT were used to simulate desired aflatoxin risk environments.

Research at ICRISAT focused on identifying mechanisms (at crop, pod, seed testa and cotyledonary level) contributing to seed infection by *A. flavus* and aflatoxin production, and screening selected peanut germplasm for LAR traits. Genotype x environment (GxE) interaction for low-aflatoxin traits was investigated in the field and in growth chambers at ICRISAT, as well as at QDPI.

Project outcomes

Research conducted during the project tested a range of peanut varieties for aflatoxin contamination responses. Doing so improved the understanding of the range of physical, physiological and biochemical traits relating to low aflatoxin risk. This also revealed major inconsistencies in aflatoxin contamination responses, limiting the ability of project scientists to meet all objectives.

Despite this genotypes with mechanisms for host-plant resistance were identified. Genotypes with resistance mechanisms to aflatoxin production have also been identified. Drought responses of peanut varieties and the extent these factors play in contamination have also been determined. Lines with relatively consistent low-aflatoxin risk have been identified, suitable for Indian and Australian conditions. It is expected these lines will be used in future breeding activities in both countries.

The inconsistencies in aflatoxin responses revealed the complexity of Genotype by Environment problems. A range of factors, from soils to insects and climate all play a part in triggering aflatoxin responses. Research undertaken during the project will go some way to developing more structured approaches to future GxE studies, aiding in breeding and genetic research.

Other South Asian countries: multilateral

ASEM/1998/081: Global Mountain Program on: Investigating issues and options for managing sustainable livelihoods on marginal mountain farms

Overseas Collaborating Countries:	Bhutan, India, Nepal
Commissioned Organisation:	International Centre for Integrated Mountain Development, Nepal
Project Leader:	Dr Pradeep M Tulachan
Collaborating Institutions:	Ministry of Agriculture, Bhutan
	Council for Advancement of People's Action and Rural Technology, India
	GBP Institute of Himalayan Environment and Development, India
	Himachal Pradesh Agricultural University, India
	National Centre for Agricultural Economics and Policy Research, India
	Centre for Resource and Environmental Studies, Nepal
	Winrock International, Nepal
Project Budget:	$447,120
Project Duration:	01/07/1999 to 30/09/2002 (Project extended from 01/07/2002 to 30/09/2002)
ACIAR Research Program Manager:	Dr Ken Menz

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Project outcomes

The researchers grouped major issues for each region under three headings: socio-economic, technological and policy related issues.

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Commissioned Organisation:	International Center for Agricultural Research in the Dry Areas, Syria
Project Leader:	Dr Amor Yahyaoui Phone: + 963 21 221 3433 Email: a.yahyaoui@cgiar.org
Collaborating Institutions:	Agriculture Victoria, Australia Department of Agriculture, Western Australia, Australia NSW Agriculture, Australia University of Adelaide, Australia
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Project Duration:	01/07/2001 to 30/06/2004
ACIAR Research Program Manager:	Dr Colin Piggin

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LWR1/1997/016: Conjunctive water management for sustainable irrigated agriculture in South Asia

Overseas Collaborating Countries:	Pakistan
Commissioned Organisation:	International Water Management Institute, Sri Lanka
Project Leader:	Dr David Seckler, Dr Vilma Horinkova Phone: +94 1 867404, Phone: + 92 42 5410050 Email: IIMI@cgnet.com, Email: v.horinkova@cgiar.org
Collaborating Institutions:	Pakistan Council for Research on Water Resources, Pakistan CSIRO Land and Water, Australia
Project Budget:	$625,818
Project Duration:	01/07/1998 to 31/03/2003 (Project extended from 30/06/2001 to 31/03/2003)
ACIAR Research Program Manager:	Dr Ian Willett

Project background and objectives

Conjunctive water management refers to the management of waters from all sources within a water basin and leads to an increase in the amount of available water. Water considerations are major components of any program of socio-economic development and poverty alleviation for many developing countries. Governments and Development Agencies recognise this and invested heavily on water resources development projects during the twentieth century.

Currently, opportunities for further water resources development are limited, either due to the absence of water or lack of financial resources. In the meantime, due to a steady rise in population, demand for food continues to increase. Irrigated agriculture, which consumes 69 per cent of all freshwater resources, and produces 40 per cent of all food, is expected to require an additional 17 per cent of water to meet the demand for food. This water is not available from primary sources (rain, snow melt and groundwater). Further, freshwater consumption in irrigated agriculture must be reduced to meet the increasing demand for fresh water for domestic and industrial requirements. Therefore, water from all primary sources as well as from secondary sources (drainage, sewage) needs to be used conjunctively in agriculture.

South Asia had no capacity to carry out effective conjunctive management. Proper institutional and technical strategies were needed to manage water conjunctively and minimize threats to the environment. This study aimed to address these concerns. The Rechna Doab of Pakistan and the Coleambally region in Australia were chosen as the study sites because while both have access to surface and groundwater supplies, overall water is the limiting factor for agricultural production. Institutional reforms in the water sector were under way in both countries, and both study areas fell in semi arid environments with little natural drainage due to flat topography. Thus, the environmental consequences of irrigated agriculture (salinity and waterlogging) were similar in the two regions.

This project aimed to identify and test combinations of technologies, institutions and management tools to conjunctively manage surface and subsurface water. Project objectives were to maximise the short-, medium-and long-term agricultural productivity of water, facilitate water savings and ensure environmental sustainability of irrigated areas in South Asia.

Project outcomes

In order to disseminate the results of the project to various stakeholders, researchers and policy makers a two-day workshop was held in 2002 in Lahore. Stakeholders heard presentations and were later involved in extensive discussions. In total, 16 papers were presented in the workshop. On the

first day the 16 papers addressed modelling conjunctive water management and technical issues regarding conjunctive water management, drawing on the experience in Pakistan and Australia.

The four papers on the second day of the workshop covered the economic and institutional aspects of conjunctive water management. This was followed by panel discussions to formulate strategies and recommendations for sustainable conjunctive water use. During the third session of the workshop participants received hands-on training and demonstrations of technical and management tools.

As a result of the study the Punjab Irrigation Department (PID) has adopted institutional arrangements identified by the project team. As well the Coleambally Irrigation Cooperative Limited (CICL) has adopted shallow and deep groundwater options, and the CICL reorganised the environmental zones on the basis of groundwater management zones defined by the project team.

SMCN/2002/028: Stress tolerant wheat and maize for Afghanistan: Seeds of strength

Overseas Collaborating Countries:	Afghanistan
Commissioned Organisation:	International Maize and Wheat Improvement Center, Mexico
Project Leader:	Dr Sanjaya Rajaram Phone: + 52 55 5804 2004 Email: s.rajaram@cgiar.org
Collaborating Institutions:	International Maize and Wheat Improvement Center, Afghanistan
Project Budget:	$1,000,000
Project Duration:	01/07/2002 to 30/06/2004
ACIAR Research Program Manager:	Dr Christian Roth

Project background and objectives

Afghanistan is one of the poorest and least developed countries in the world. Food production fell by more than 50 per cent between 2000 and 2001, the legacy of war, drought and the destruction of irrigation and other infrastructure. Critical seed stocks have been depleted. The result is a nation that relies heavily on food aid from international donors.

More than half the country's total crop production is winter wheat; maize, a summer crop, is the next most important cereal crop. Together wheat and maize constitute more than 80 per cent of annual crops. International Maize and Wheat Improvement Center (CIMMYT) programs in various countries have extensive information on cultivars in the Afghanistan region and have already identified materials with improved yield and disease resistance.

The aim of this project is to improve maize and wheat production in Afghanistan. In particular, the project will provide small farmers with new cultivars and the seed of improved varieties of wheat.

Project outcomes

The project met the immediate goal of identifying suitable varieties of wheat and maize. Using varieties collected and trialled over the past two decades, CIMMYT procured 300 tonnes of wheat seed and 2.5 tonnes of maize seed suitable for Afghan conditions. These were delivered in time for the planting season. Importantly this delivery of suitable maize and wheat restored farmers' confidence in both growing crop varieties and in CIMMYT and the project team members.

Once planted, the wheat was evaluated, both on-farm and on-station. Quantitative data on yield was combined with farmers' qualitative assessments to help identify suitable varieties for wider release. The first of these releases, the bread wheat Sohl 2 (Sohl meaning peace) was released in 2003. Yields of Sohl 2 averaged 50 per cent above those of existing varieties, this yield bonus quickly being passed along farmer networks. Seed multiplication schemes, both formal and informal, helped match this growing demand for the new variety.

Good maize varieties were also identified after on-farm and on-station trials and evaluation. Participatory variety selection trials for maize were conducted to provide farmers with the means of assessing cultivars themselves. During the first year of operation it became clear to the project team that Afghani scientists also needed training and this was added into the project activities.

The Ministry of Agriculture entered into an agreement to identify scientists for training, with the scientists agreeing to continue to work for their then employer for another two years after completing this training. A total of 15 scientists received training, beginning with language skills followed by international courses in relevant areas of breeding and crop evaluation. Importantly many also built networks with relevant international agencies. In-country Ministry of Agriculture staff received a variety of on-farm training including learning diagnostic survey skills of yield limiting factors.

Research into wheat rust and evaluating Afghan cereal landraces held in Australia and at CIMMYT was limited by the local conditions (drought in Afghanistan) and a lack of scientific capacity. The capacity building undertaken in the project has established a small, but important, platform of knowledge and skills to support future research in both these areas. International trials and nurseries of crop varieties established both through and outside the project are also being supported by this capacity building. In 2002-03, 35 variety trials and wheat nurseries were established at 6 sites and by the 2003-04 growing season 15 trial sites were up and running. The Darul Aman Research Station near Kabul is now hosting wheat germplasm nurseries and wheat trials.

Projects under development

as at 1 December 2004

India: bilateral

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

AS1/2003/032 The development of a model for the extension and consolidation of the protected protein feed supplement for dairy production in India

CIM/2004/033 Crop and weed ecology under changing tillage and crop establishment systems in India and Australia

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

SMCN/2002/100 Water harvesting and better farming systems for benefit of watershed small farmers in eastern India red soil plateau

SMCN/2002/101 Improving rural livelihoods in SAT watersheds through participatory approaches to enhance rainwater management and groundwater availability for sustainable use

India: multilateral

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

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

Pakistan: bilateral

SMCN/2004/035 Evaluation, refinement and promotion of technology for direct drilling into rice and other heavy stubbles in Pakistan and Australia

Afghanistan and Pakistan: multilateral

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

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. Titles marked with an asterisk may also be downloaded from ACIAR's website, www.aciar.gov.au.

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)*

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)*

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)*

Research Notes

27 Assessing the extent and causes of degradation in India's arid rangelands (2004)*

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)*

Impact Assessment Unit Working Papers

24 Project development assessment: prolific worm-resistant meat sheep for Maharashtra, India and Australia (1995)*

28 Project development assessment: an economic evaluation of the potential benefits of integrating apomixis into hybrid rice (1997)*