Australian Cotton Cooperative Research Centre

Annual Report 2002/2003

CRC AUSTRALIA

Established and supported under the Australian Government Cooperative Research Centres Program

Cotton CRC

Contents

Mission Statement

Mission

To enhance the development and growth of the Australian cotton industry through the application of collaborative research, education and the adoption of sustainable farming systems.

Objectives

To enhance the prospects for expanding cotton production by researching viable and environmentally responsible cotton production systems for new regions in Western Australia, the Northern Territory and north Queensland. To develop solutions to specific regional environmental problems prior to promoting commercial activity.

To research and develop innovative technologies which provide an improved range of options for environmentally acceptable crop management and bioremediation.

To develop strategies for cotton production that encourages efficient use of resources while minimising inputs and the impact on the environment.

To have a coordinated national network of extension, support and education services which utilises modern techniques and delivery systems for the transfer and adoption of new technology by the cotton industry and to advance the knowledge and skills of those supporting the industry.

To develop innovative technologies for bleaching of pure cotton and cotton blends, continuous and semi-continuous procedures for the dyeing of cotton/wool fabric and a fibre modification technique for handling cotton sliver that incorporates a mercerisation process, that are environmentally and economically favourable.

Chairman's Foreword

This Annual Report is the fourth from our Australian Cotton CRC and marks ten years of continuous Cotton CRC research, education and extension.

We have very good reason to be proud of the achievements of those ten years of collaborative effort which have generated scientific discovery and rapid industry uptake.

Within the cotton industry, research directions are driven by grower demand with close, organised links between growers and researchers, educators and extension people. Similarly, research outcome drives grower performance. The result of this effective two way communication is an industry broadly perceived as being increasingly technologically, environmentally and socially responsive.

A technological, environmental and socially responsible perception of the cotton industry is something relatively new and definitely welcome. It is the direct result of effective and direct communication links between science and the land manager.

The Cotton CRC has developed a unique ability to communicate with people actually managing land. Some of the very people who will undertake the action needed for improved environmental outcome at catchment scale.

Nationally, cotton can have only a limited impact on its own; the communication tools we now use and which are now making a difference, will soon reach a plateau of effectiveness unless cotton attracts partners from within the other major industries of grain, grazing and urban interest, with whom we share our catchments. For example, the advantages delivered by widespread Integrated Pest Management, Best Management Practice and Area Wide Management adoption within cotton areas will need the participation of neighbouring farms with enterprises other than cotton, in order to continue to climb the scale of effectiveness.

The unique cotton communication linkages provide the means through which cotton and research with future new partners can be delivered directly to land managers to move toward the achievement of national environmental objectives within the catchments in which cotton is grown.

Our new Program 6 is the first step in that direction and the next steps are in active planning.

Evan Cleland
Board Chairman.

Executive Summary

The past year has been one of both consolidation and change. Consolidation and progress with many aspects of our research, education and extensive activities, and change with the establishment of a new research program, development of some important new initiatives and a change of CEO.

We also saw the Howard review of the CRC Program itself which has given ringing endorsement for the collaborative outcomes achieved across the diverse CRCs now operating, but also indicates some areas for further improvement. No doubt these will be reflected in the next call for CRC proposals, anticipated for October.

A high profile for Australian cotton research

This year saw Australia's strong standing in international cotton research recognised at the Third World Cotton Research Conference held during March 2003 in Cape Town, South Africa. With 38 countries represented Australian researchers were responsible for 15% of the papers, including several plenary presentations. International colleagues were impressed with the quality of our outcomes and the collaborative approach which supports our work.

Northern Challenges

With the attention of northern environmental groups and considerable interest from the wider community the last year has been a challenging one for our northern researchers. Following some disappointing yield results in 2002, the research team spent considerable time during the post season review in Darwin analysing all past research and agreeing on a best-bet management strategy for agronomy and pest management for future research. Outcomes of all past research form the basis for a rudimentary NORpak which will be refined over coming years as a manual for cotton production in tropical Australia.

A significant boost for NT research has been an alliance between the Cotton CRC and the Peanut Company of Australia (PCA) which now allows large scale on-farm research at Katherine in association with PCA growing peanut production enterprise. Peanuts and cotton may be a promising rotation for the future. Likewise the resumption of research at Broome allows some preliminary information on new transgenic cottons to be gained in that environment. These positives helped to counter the negative impact of reductions in Cotton R&D Corporation funding due to the drought and ongoing uncertainties about Ord Stage II.

Research delivering to industry

Much of the research in our "Innovative Technologies" and "Sustainable Farming Systems" programs together with our efforts in Extension are now delivering significant benefits to the cotton industry. More sustainable approaches to pest management is a key example where Integrated Pest Management (IPM), transgenic cottons, and adoption of area-wide coordinated approaches has contributed to a dramatic reduction in pesticide use over the last five years (see Highlights). These advances arise only through strong partnership with industry and are clearly a model for the future, where broader engagement with other agricultural industries will be required in order to gain most benefit. Commercialisation of a novel attractant for management of *Helicoverpa* – the first commercial product from Cotton CRC research - will see the industry with another tool for the IPM toolkit from the 03/04 season.

Water remains a key outcome area. In Queensland, the Rural Water Use Efficiency project (RWUE) coordinated by the CRC in partnership with DNRM and DPI, has achieved a 10% improvement in water use efficiency (WUE) among irrigators in the cotton and grains industries. Again a reflection of what can be achieved through partnership of effective extension staff, committed growers and quality research.

Enhancing and Managing Agricultural Ecosystems

Building on efforts in the previous year we have established a new program (Program 6 – Enhancing and Managing Agricultural Ecosystems) to address key environmental challenges (water, vegetation, biodiversity) now confronting agriculture. Lead by Assoc Prof Nick Reid (UNE) and Guy Roth (CRDC), the new program will equip cotton growers to manage their whole farm environment. While resources for the new program remain limited it is closely aligned with government initiatives in natural resource management and represents a foundation for future CRC development.

Cotton Processing Research

With a brand new $1 million cotton processing facility at Geelong, our Textile research program has commenced developing strong links with international spinners in a project which explores their perceptions of Australian cotton quality and the key factors which influence buying decisions. Outcomes from CRC funded research into novel bleaching techniques for cotton and cotton blends now has IP protection and several potential applications across cotton and other cellulosic materials are being explored. The real challenge remains to transfer outcomes from textile research to the processing industry, potentially overseas, in ways that advantage Australian cotton.

Annual Review and Awards

Our 2003 annual review of projects was held this year in Armidale, where some CRC participants found July a little chilly. Concurrent sessions focused on four themes - Farming Systems, Insect Management, Enhancing Agricultural Environments, Weeds and Diseases. By allowing more presenters and greater depth of discussion the format was a highly useful occasion for both review and planning. Postgrad students also enjoyed the opportunity to present their projects to smaller, more specialised audiences.

Our annual awards this year went to:
Innovation – Prof. Ivan Kennedy, Dr. Angus Crossan and Mick Rose for their application of many years of research on pesticide bioremediation to an innovative approach to remediation of irrigation tailwater using on-farm wetlands planted with specifically selected plants – pesticide reductions and biodiversity benefits in one. Collaboration – the team of Dr. Stephen Allen (CSD/CSIRO), Dr. David Nehl (NSW Agriculture) and Dr. Joe Kochman (QDPI) for their production of the Integrated Disease Management (IDM) Guidelines and their ongoing leadership of our battle with Fusarium Wilt. Corporate Citizenship – Ingrid Christiansen. As coordinator of the National Cotton Extension Network, Ingrid is often a public face of the CRC. Finally we recognised the long running efforts of David Larsen, coordinator of the Technology Resource Centre (TRC), with the award for Communication to industry. David's efforts have ensured the TRC provides excellent information delivery in a number of formats to industry. This year he developed the CottonPAKS CD which puts all the CRC written packages on one searchable CD.

Other significant awards this year went to three Cotton CRC staff, Nicky Schick (Research Liaison Officer, Narrabri), Andrew Davies (PhD student, UQ) and Sven Delaney (PhD student, Adelaide), each awarded an AFFA Science and Innovation Award for Young People. The awards support individual projects which combine personal development with benefits for the cotton industry.

A look to the future

As this is my last CEO report for the Cotton CRC, following my decision to step down from July 1, 2003, I extend my best wishes to all members of the CRC for a productive future. Guy Roth, as CEO from September 2003 will have an interesting and demanding path ahead.

Planning for a re-bid for the Cotton CRC is now well advanced. A number of new participants have been identified, and a broad structure and focus agreed, which would see an expansion in both industry and community involvement. Hopefully a third round Cotton CRC will be the result of the great deal of work now required to convert good ideas into a winning bid.

I also take this opportunity to urge the cotton industry to maintain its leadership role in agriculture, maintain momentum towards sustainability through widespread adoption of the industry's BMP program and continued support for the Cotton CRC's outstanding research and extension community which supports it.

Dr. Gary P Fitt
Chief Executive Officer

The Australian Cotton CRC's Annual Award for Innovation presented to Prof. Ivan Kennedy, Dr Angus Crossan and PhD Student Mick Rose.

The Australian Cotton CRC's Annual Award for Corporate Citizenship went to Ingrid Christiansen.

The Australian Cotton CRC's Annual Award for Communication to the Industry went to David Larsen.

The Australian Cotton CRC's Annual Award for Collaboration went to Dr Stephen Allen, Dr David Nehl (Pictured above) and Dr Joe Kochman.

Highlights

Cotton CRC's New Program - Enhancing Agricultural Environments

Program 6 is a new CRC Program, conceived in May 2003, that combines various research projects on environmental issues to create a new stand-alone research Program entitled "Managing and Enhancing Agricultural Ecosystems."

The Program, with initial funding of $580,000, has been jointly managed by Guy Roth from the Cotton Research and Development Corporation, and Associate Professor Nick Reid from The University of New England.

The aim of the new Program is to strengthen the CRC's profile in environmental research, and provide a sound platform for future growth by building on the CRC's strengths in the national resource management arena. The key objective is to minimise the environmental impact of cotton farming.

Water birds on cotton irrigation channels.

The Program is designed to equip cotton growers with new knowledge, skills and understanding necessary to extend the cotton industry's environmental program "BMP" to achieve excellence in environmental management, and subsequently, recognition of the environmental sustainability of the industry at the catchment scale.

The Program has five individual themes: deep drainage and salinity; greenhouse gas profile and emissions; wetlands and pesticide remediation; native vegetation and biodiversity; and ecosystem services.

Many of the CRC's core partners as well as others are involved including CSIRO Land & Water, Plant Industry and Entomology; the Queensland Department of Natural Resource Management; NSW Agriculture; and the Universities of Sydney and New England.

Specific projects relating to deep drainage and salinity include understanding salinity threats; hydrological modelling to aid irrigation practices; and measuring the influence of water quality on deep drainage.

Greenhouse gas studies include a baseline assessment of emissions, and sequestration of sub-surface carbon.

Wetlands and pesticide remediation studies involve the use of on-farm wetlands, and using enzymes to breakdown pesticide residues.

Native vegetation and biodiversity research involves studying the impact of soil microbes on diseases; observing the effect of cotton defoliants on native flora; recording the benefits of native vegetation in harbouring beneficial insects; and researching the role of bats as a natural control agent for *Helicoverpa spp*.

Ecosystem services research initially involves an ecological and economic assessment of cotton production inputs and outputs in the Gwydir Valley.

Milestones achieved in this suite of projects now embraced by Program 6 can be found in Program 3, from where most Program 6 projects originated prior to May 2003.

Cotton and Peanuts Join Forces.

The vastly different tropical environment, soils and growing conditions in northern Australia, mean that cotton production practices and agronomic management techniques applied in southern Australia, cannot simply be transferred north.

This is best demonstrated in the following diagram which outlines a typical calendar of operations from planting to harvesting in a northern environment. The main difference being that cotton is grown through the winter months as opposed to the summer months in southern Australia.

This diagram shows wet season cover crops and rotation crops are vital ingredients in the northern cotton production systems, particularly in relation to soil fertility, management and preservation, and in controlling soil erosion.

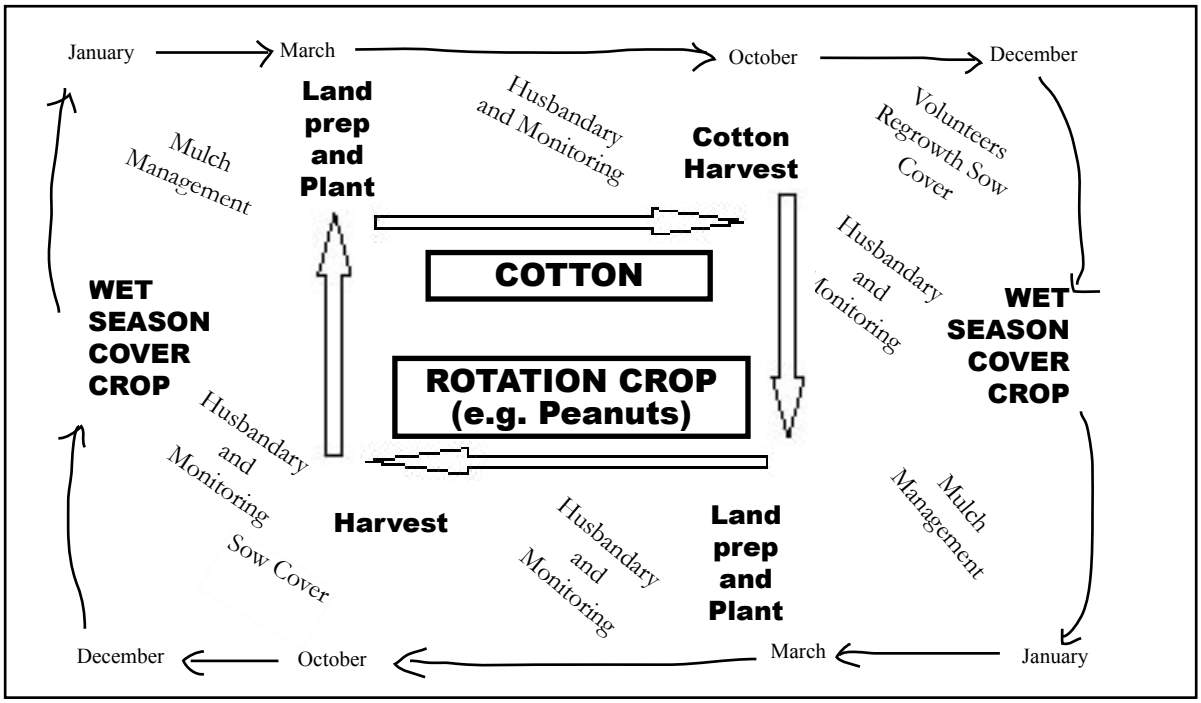
Peanuts have been identified as a potential cover crop for the October to March period. Fortuitously, the Peanut Company of Australia (PCA) is developing peanut production in the NT to help supply expanding markets for Australian peanuts, and to supply peanuts for processing out of season to those produced in Queensland.

The PCA's involvement in the Territory follows research by the Northern Territory Department of Business Industry and Resource Development (DBIRD), which showed that winter-grown, irrigated crops were the most profitable, in that higher yields and better quality nuts were produced in winter than in summer.

As part of its ongoing strategy to produce peanuts out of season, the PCA purchased a farm near Katherine, including centre pivot irrigators, and produced its first crop in 2003.

Following negotiations, the Australian Cotton CRC and CRDC developed a research involvement with PCA, for the mutual benefit of the three parties. Subsequently, the PCA agreed to lease a 30-hectare centre pivot irrigator to the cotton research program, with the aim of defining the role for peanuts as a cover crop in northern cotton production systems.

This should result in a WIN/WIN situation for both the Cotton CRC and the PCA. The Cotton CRC will establish the role for peanuts in northern cotton production and the PCA will determine the role for cotton as a profitable rotation crop for use with peanuts.



Hypothetical dry season cotton farming system for the Australian semi-arid tropics.

Aerial view of centre pivot irrigation near Katherine.

Centre pivot irrigation of peanuts near Katherine.

Potassium trial at 'Nordsten' near Katherine.

Centre pivot irrigating cotton near Katherine.

Peanut harvest at 'Nordsten' the Peanut Company of Australia's farm near Katherine.

Attractants for Helicoverpa moths – a new management tool

Recent research within Program 2 in the Australian Cotton CRC, based at the University of New England, has developed a tool to reduce oviposition pressure by taking adult female *Helicoverpa* moths out of the population, using plant volatile chemicals to attract-and-kill female *Helicoverpa* moths.

Plant-based attractants can be used in an attract-and-kill system in combination with a small amount of toxicant. Moths are lured to the attractant and, upon contact or ingestion, are killed by the toxicant. Blanket coverage is not necessary, thus the amount of insecticide can be significantly reduced.

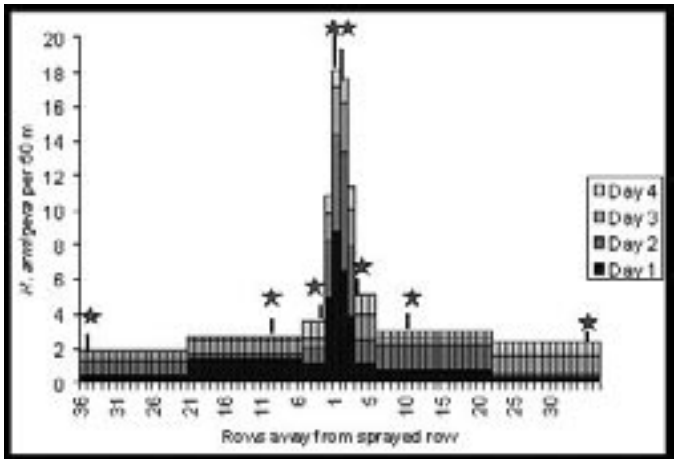
Another potential use of attractants is in an attract-and-disseminate system, where instead of a toxicant, a specific pathogen is used. Once the moths are contaminated with the pathogen, they are then released, hence spread the pathogen. We can also envisage applications for attractants in conjunction with trap crops, repellants or anti-feedants to manipulate *Helicoverpa* populations.

After a long series of such trials, we identified a number of synthetic blends which gave levels of attraction comparable to some of the most attractive plants. It is important to note that our blends are not mimics of particular plants, as are those from the US. We have combined the best components from a number of different plants, producing what we call a super-blend: a combination of plant volatiles not normally found in nature.

Assoc. Prof Peter Gregg UNE with the three-wheeled motor cycle and low pressure pump sprayer used to apply attractant.

Results

The highest numbers of moths killed were found in the furrows immediately adjacent to the treated rows. However, significant numbers were also found at 35 rows away, and there were almost as many at this distance as there were at 3 and 10 rows away. This indicates that while many moths are killed very quickly, some can move considerable distances after contacting the attractant. Counting only the rows adjacent to the sprayed one is likely to substantially underestimate the kill.



Numbers of dead H. armigera moths collected over four days after the first spray at "Wamara". Sampled rows are indicated by stars

Where to from here?

The results of these first large-scale trials were encouraging. Our attractants can regularly kill significant numbers of both *Helicoverpa* species, and other noctuid pests (among the other species we recorded were cutworms, armyworms, loopers and rough bollworms). The numbers killed are likely to reflect the local moth population, and therefore we need to determine how best to time applications.

The detection of both local and district impacts on *Helicoverpa* pressure suggests that if larger areas were treated, perhaps starting earlier in the season, we might be able to substantially reduce egg pressure over a wide area and for a long period.

The Australian Cotton Cooperative Research Centre has signed a commercial agreement with private company Ag Biotech Australia to develop, manufacture and market the new attractant blend officially launched as 'MAGNET'.

Other highlights from Program Two.

Recent achievements include demonstration of the consistent high efficacy of two-gene cotton; characterisation of the concentration and persistence of Cry1Ac/2Ab proteins; and the development and acceptance of a Bollgard II management strategy.

In separate trials, DNA was successfully delivered to *Helicoverpa Armigera* embryos by microinjection, and mass DNA transfer by particle bombardment with a new gene gun was attempted

A single gene encoding an enzyme that degrades endosulfan was also isolated and cloned, to evaluate its efficacy in cleaning up contaminated run-off water (successful), but proved too expensive for field evaluation.

A rapid and accurate DNA diagnostic test for fusarium was developed and used in studies with bulk export cottonseed. Validation tests are in progress. This test should allow rapid fusarium diagnosis from plants, soil, seed and water, hence improved screening and monitoring capability, and development and implementation of improved management and control strategies.

The potential benefits of induced resistance for fusarium and black root rot control was also demonstrated, as was the benefit of biofumigation for Black Root Rot control, but proved ineffective for fusarium control.

A major disease survey was conducted in NSW and Queensland (for the 20th consecutive year). Seedling mortality in NSW was the highest since 1989, being highest in the Lachlan Valley and lowest in the Gwydir. Fusarium wilt expansion continues, and could affect 90 per cent of NSW farms within a decade.

Black Root Rot was found to be in epidemic proportions in NSW, and is now found in all production areas in Quensland and NSW, where the Namoi and Macquarie Valley are worst affected and also more than 50 per cent of fields in the Gwydir and Macintyre regions.

Declining Pesticide Use an Outcome of Program Three Research.

Since its formation, the Cotton CRC has worked towards the development of tools to assist in the implementation of Integrated Pest Management (IPM), working closely with industry and growers to develop practical, sustainable IPM systems.

This objective has several key components, namely:

- Conserving and using beneficial insects
- Keeping track of insects and damage
- Growing the crop efficiently
- Preventing the development of insecticide resistance
- Managing alternative crop and weed hosts
- Using trap crops
- Communicating the positive economic and environmental benefits of IPM to industry

The aim and focus of all these research segments has been ultimately to reduce the cotton industry's dependence on insecticides, through initiatives implemented both during the cropping season, and during the non-growing period, hence the development of a farming systems, rather than focusing solely on the traditional 'entomology-centric' approach.

Trap crops, selection of optimal planting time; regular monitoring of pests, predator and beneficials; adherence to damage thresholds; water management; selective use of insecticides; and the use of Bt varieties, have all been major growing season contributors to achieving these objectives.

Pupae destruction; crop rotation; weed, regrowth, fertiliser and nutrition management; and variety and seed insecticide treatment choice, have been major off-season strategies.

As shown in the following graphs there has been a marked downward trend in the number of insecticide spray applications in recent years, especially endosulfan, and an increasing trend towards more selective insecticides. Some insecticides have in fact been replaced with biological insecticides.

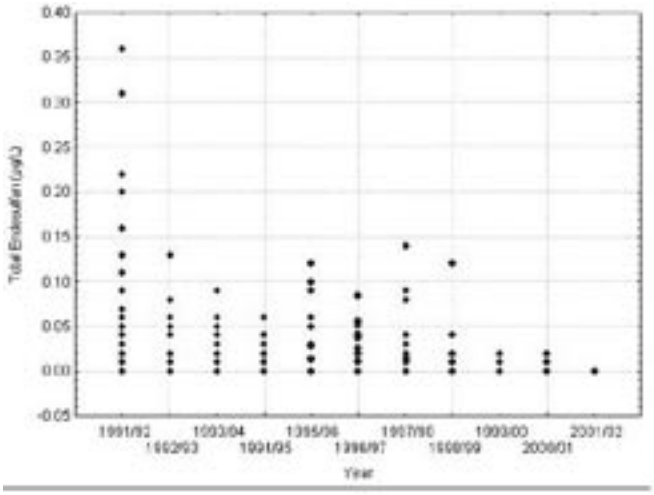
This reduction in the overall amount of active ingredient per hectare (a.i) can be contributed in part to the use of BT cotton; an increased commitment to IPM by growers, and consultants (now covering more than 50 per cent of the cropped area); reduced use of older products that required higher levels of a.i for efficacy (e.g. endosulfan, organophosphates, and carbamates); and possible lighter insect pressure over the past five years.

These developments are positive for the further expansion of IPM and the economic and environmental sustainability of cotton production, but we know from past experience that the

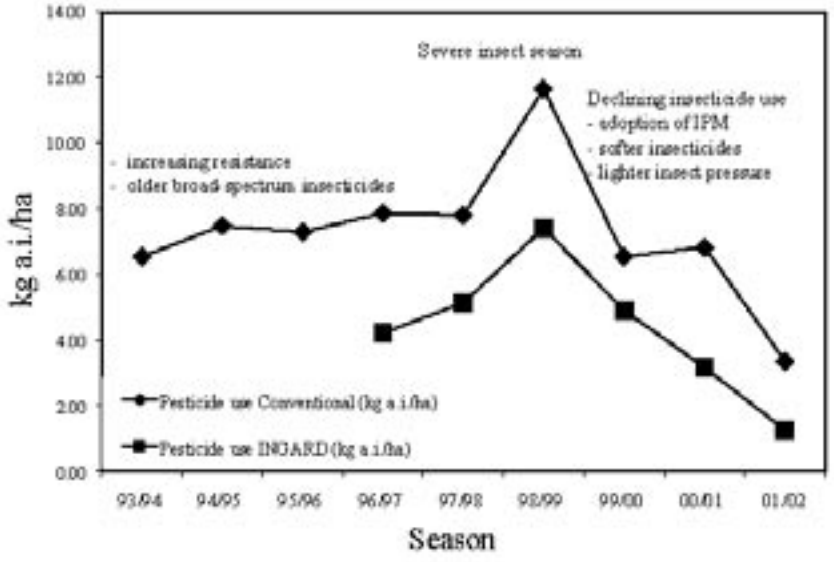
pest complex is dynamic and constantly changing.

Already there is evidence that sucking pests, formerly suppressed by *Helicoverpa* sprays, have potential to present new challenges to be incorporated in future IPM strategies.

While the ongoing improvement of transgenic two BT gene cotton (Bollgard II® varieties), will continue to support IPM, the farming systems approach to IPM now takes on increased significance, as the industry comes to grips with that and associated technology such as Roundup Ready varieties.



Total Endosulfan found in the Namoi River at Bugilbone (Source DLWC 2003)



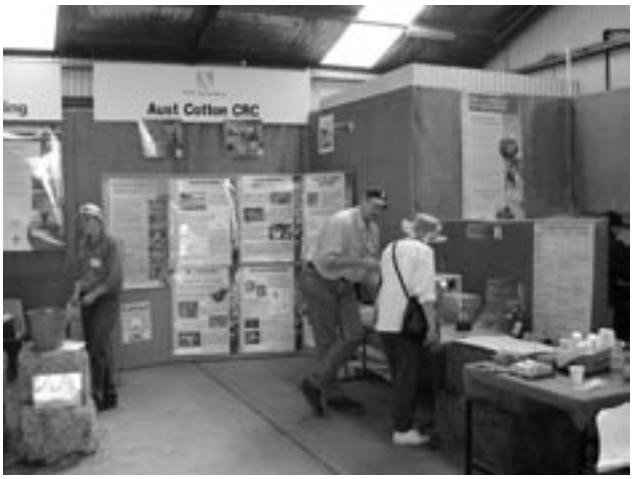
Average amount of active ingredient (a.i.) of insecticide per hectare for conventional and Ingard cotton crops in Australia, 1993 - 2002. Reductions are due to reduced insecticide use due to adoption of IPM, a change in insecticide use away from broad spectrum insecticides toward more selective insecticides (including biological that do not contribute to (a.i.) and to some extent lower insect pressure. (Graph prepared using data collected by Cotton Consultants Australia as part of the annual Cotton Research and Development Corporation's report on Performance of INGARD® cotton in Australia) (Source: CCA Market Audit Surveys 2002, 2003.)

Program Four Highlights

The objectives of Program 4 are to enhance and promote awareness and adoption of new technologies to growers, consultants and the community via research, extension and training forums, workshops, courses, area wide management programs, scientific exchanges, decision support systems such as the CRC website, individual Decision Support System PAKS, the Cotton PAK CD, and various guides, guidelines and publications.

Program highlights during 2003 included:

- Consolidation of an integrated national extension network with linkages to important industry organisations such as the ACGRA, CGA, CRDC, Cotton Australia, Consultants and seed companies;
- Hands-on involvement in this network by a team of almost 30 extension specialists including a national cotton extension coordinator, an IPM training coordinator, 11 water use efficiency extension officers, 10 industry development officers, 5 farming systems officers, 2 spray application extension officers, and one technical officer;
- A 10 per cent increase in water use efficiency utilising best irrigation management practices pursued under the Queensland RWUE and grains adoption project, resulting in water savings of 67,855ML, an improvement in bales produced per ML of 12.8 per cent, leading to increased production of 113,996 bales valued at $57 million.
- Successful completion of 3 pilot integrated pest management short courses, and scheduling of a further 6 courses designed to graduate 68 participants;
- Continued expansion of Australia's only certificate and post-graduate certificate in Rural Science (Cotton Production), in conjunction with the University of New England, where 133 participants have now graduated;
- Continuation of the summer scholarships and scientific exchanges program, with the latter culminating in 19 international visitors and 17 staff exchange visits;
- Development of a valuable industry data base (via the Technology Resource Centre) of 2800 clientele of which 61 per cent are growers;
- Successful uptake of major decision support system PAKS including 1169 copies of CottonLOGIC, 935 copies of ENTOpak, 710 copies of SOILpak, and 686 copies of NUTRIpak, as well as liberal supplies of SPRAYpak, IDM Guidelines, the Dryland Production Guide and various miscellaneous publications;
- Significant development of the CRC website, including inclusion of a new across- disciplines search facility;
- Review of the strategic plan for Program 4, the objective being to utilise and enhance existing national networks of extension, support and educational service to optimise the adoption of new technology and practices by cotton growers.
- An integral part of the revised strategic plan is further consolidation of the national cotton extension network, greater emphasis on catchment issues and on environmental management, better targeting of short courses, particularly in relation to the service industries, and the inclusion of weed and disease management within IPM courses.



Mark Hickman the Australian Cotton CRC's IDO in Gunnedah at the Cotton CRC's stand at the AGQUIP field days in August 2002.

Rachael Holloway, CRDC, John Watson, cotton grower and Ingrid Christiansen, Cotton CRC at the women in cotton field day, Boggabri 2003.

The Australian Cotton CRC display at the 11th Australian Cotton Conference in Brisbane to which 1,400 growers, consultants and industry personnel attend.

CRC Cotton Production Course Business Plan

The Post Graduate Certificate and Certificate in Rural Science (Cotton Production) represents a unique partnership between the Australian Cotton Cooperative Research Centre (CRC) and The University of New England (UNE). The course has won many awards including the Business and Higher Education Roundtable Award for collaboration.

It is the only course offered in Australia at university level targeting the tertiary training needs of cotton growers and associated service industries. The course provides students with agronomy skills and knowledge of the natural, human and economic resources necessary for sustainable cotton production.

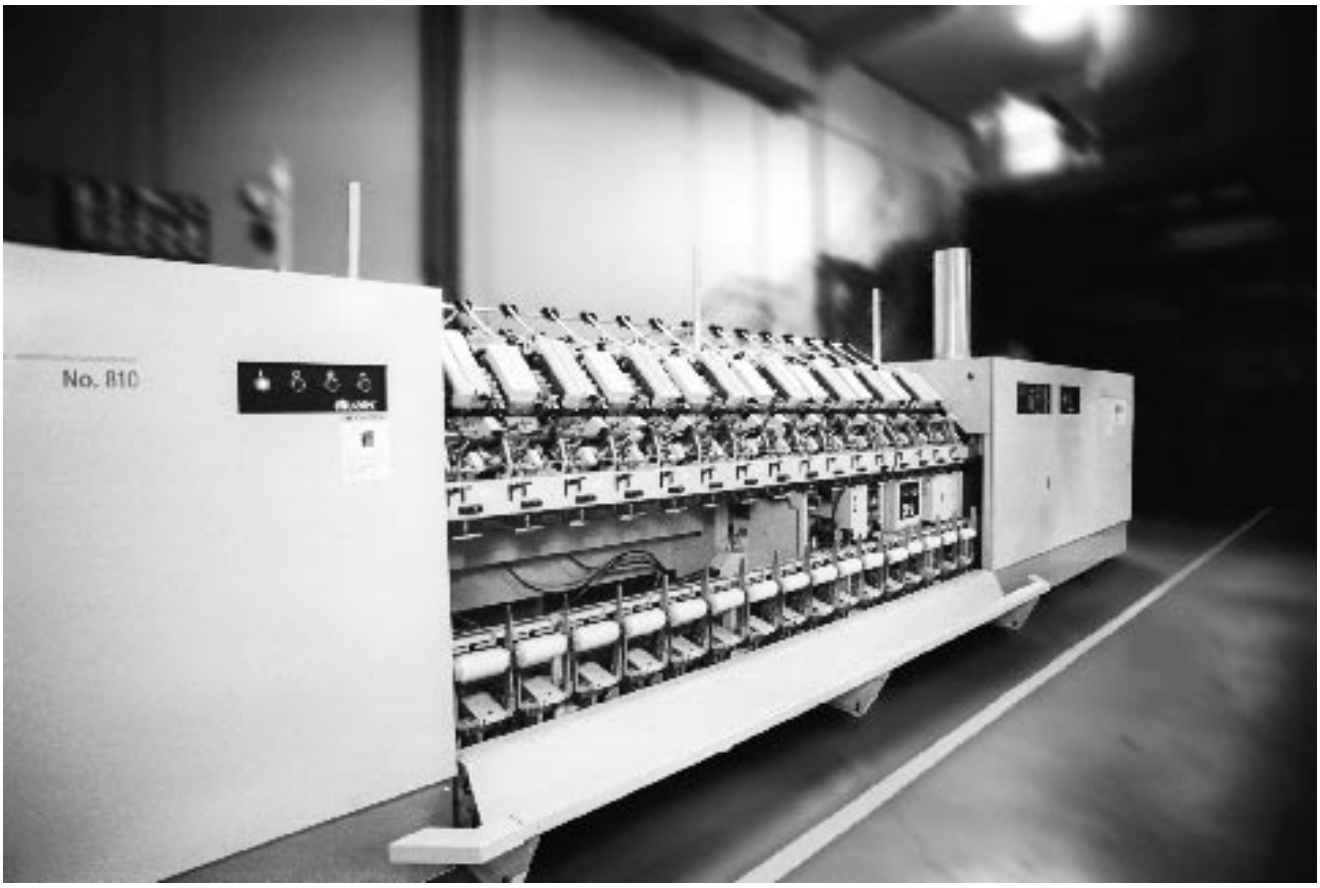
Historically, the majority of graduates have come from on-farm personnel that include all sectors of the industry.

Traditionally, the Course has enjoyed generous financial and in-kind support from the Cotton CRC. This financial support is set to terminate in 2006.

To ensure the survival of the Course, a Business Plan has been developed to help pursue future funding options, including subsidies, sponsorships, partnerships, increased enrolment fees, and commercialisation of intellectual property; review target markets; develop licensed short courses; maintain the monopoly position of the Course; and provide it with an international focus and flavour.

The Business Plan has identified the target customers of the Course as 1200 Australian cotton growers (77 per cent in NSW and 23 per cent in Queensland); 330 members of Cotton Consultants of Australia; family and corporate farm managers; farm and industry agronomists; chemical, fertiliser and seed company employees; and potentially international students from a wide range of countries including the African Continent, China, Pakistan, India, Greece and South America.

The task ahead is to gain industry agreement on these objectives and directions, gather support for the overall marketing plan, and equip the Course coordinators with the resources to implement this blueprint for the future.



Vortex Spinning Machine - is the latest generation of spinning technology, considered faster than either ring spinning or open end spinning, the two systems used for cotton spinning.

Highlights from Program Five – Cotton Textile Research.

Highlights of the CRC's textile and fibre technology Program included:

- Commissioning a fully operational commercial processing mill at Geelong enabling the production of dyed fabric from lint;
- Interaction with technical managers in 25 companies processing Australian cotton, representing 63 mills in Japan, South Korea, Thailand and Indonesia, to define and resolve fibre property and processing performance issues in spinning Australian cotton;
- Benchmark Australian cotton against cotton from competitor countries such as the USA, China and Zimbabwe in overseas mill trials;
- Implementation of trials in mills and at CSIRO to confirm and resolve technical issues;
- The development (patent pending) of novel bleaching technology involving a simple chemical additive, superior final product performance and energy savings in processing, with potential commercial relevance and royalty benefits also in the paper pulp industry;
- Development and trialling of prototype equipment for measuring lint fibre quality, allowing micronaire measurements to be replaced with or augmented by fibre fineness and maturity measurements.

The major objective not achieved was the Program's failure to attract a Ph.D student to oversee an important project linking farming systems to fibre quality and textile performance, although preliminary work on the project has commenced. Attracting PhD students to regional areas remains a high priority for the Cotton CRC.

Structure and Management

The Australian Cotton Cooperative Research Centre is an unincorporated joint venture between:

- CSIRO Plant Industry, Entomology, Textile and Fibre Technology, Tropical Agriculture
- Department of Primary Industries Queensland, NSW Agriculture, Agriculture Western Australia, and the Northern Territory Department of Business, Industry and Resource Development
- The University of New England and The University of Sydney
- Cotton Research & Development Corporation
- Cotton Seed Distributors, Queensland Cotton and Western Agricultural Industries

GOVERNING BOARD

The Board's functions and powers include establishing policy and setting strategic directions; monitoring performance indicators, programs and activities; approval of annual budgets and commercial arrangements; negotiating funding; and appointment and review of the performance of the Chief Executive Officer. The Board is chaired by an independent chairman appointed by the Australian Cotton Growers' Research Association (ACGRA). The Board meets four times per year.

Non Research Providers

Chairman	Mr Evan Cleland
Cotton Research and Development Corporation	Ms Bridget Jackson
Cotton Seed Distributors	Mr Peter Graham
Queensland Cotton/Western Agricultural Industries	Mr Paul Catlow
Independent Member	Mr Bob Galmes, Bonds Industries
Independent Member	Ms Di Bentley, Liverpool Plains Land Management Committee
CEO (100% Centre funded)	Dr Gary Fitt

Research Providers

CSIRO	Dr TJ Higgins
NSW Agriculture	Ms Helen Scott-Orr
Department of Primary Industries Queensland	Dr Gus Hamilton
NT Department of Business Industry & Resource Development	Mr Bruce Sawyer
University New England/University of Sydney	Prof Peter Flood

Mr Evan Cleland

Ms Bridget Jackson

Mr Peter Graham

Mr Bruce Saywer

Prof. Peter Flood

Ms Helen Scott-Orr

Ms Di Bentley

Dr Gary Fitt

Mr Bob Galmes

Dr Gus Hamilton

Dr TJ Higgins

Mr Paul Catlow

MANAGEMENT COMMITTEE

The Management Committee, chaired by the CEO, meets four times per year as well as holding teleconferences on a needs basis. Its primary responsibility is to implement Board policies. Its responsibilities include assessing and recommending research projects to the Board; overseeing progress in research projects and achievement of performance indicators; managing resources; and overseeing education and training, information services, publications, technology transfer and commercialisation. All Program Leaders are represented on the Management Committee.

Dr Gary Fitt (Chair)	CEO	Cotton CRC
Mr Geoff Strickland Dr Michael Bange	Program One Leaders	Agriculture Western Australia CSIRO Plant Industry
Assoc. Prof. Peter Gregg Dr Stephen Allen	Program Two Leaders	University of New England Cotton Seed Distributors
Dr Lewis Wilson Prof Alex McBratney/Dr I Odeh	Program Three Leaders	CSIRO Plant Industry University of Sydney
Mr Dallas Gibb Mr Geoff McIntyre	Program Four Leaders	NSW Agriculture Department of Primary Industry Queensland
Dr Geoff Naylor	Program Five Leader	CSIRO Textile & Fibre Technology
Mr Guy Roth Assoc. Prof. Nick Reid	Program Six Leaders	Cotton Research and Development Corporation University of New England
Mr Bruce Pyke		Cotton Research and Development Corporation
Dr Colin Martin		NT Dept of Business, Industry & Resource Development

Some members of the Management Committee. Back Row Dr I Odeh, Geoff McIntyre, Dr Colin Martin and Ralph Schulze. Second Row: Dallas Gibb, Geoff Strickland and Bruce Pyke. Third Row: Assoc. Prof Peter Gregg, Guy Roth, Kym Orman and Assoc. Prof Nick Reid. Front Row: Dr Mike Bange and Dr Stephen Allen. (Absent - Dr Gary Fitt, Dr Lewis Wilson and Dr Geoff Naylor.)

NORTHERN COMMITTEE

The Northern Committee comprising the Chief Executive Officer, Program One Leaders, and other research and industry partners concerned with expansion into new regions. This committee advises the Management Committee on research priorities for Program One; ensures research expertise from other Programs flow into the new regions; and acts as a focus for interaction with northern communities and interest groups.

Mr Stephen Yeates, the Northern Liaison Officer based in Darwin, provides regular reports to, and takes direction from, the Management Committee through the Northern Committee.

Northern Committee

Dr Gary Fitt	CEO Cotton CRC
Mr Geoff Strickland (Chair)	Program Leader Agriculture WA
Dr Michael Bange	Program Leader CSIRO Plant Industry
Dr Ian Titmarsh	Dept Primary Industries Qld
Dr Colin Martin	NT Dept of Business, Industry and Resource Development
Mr Adam Kay	Cotton Seed Distributors
Mr Stephen Yeates	Research Coordinator/Liaison Officer CSIRO Plant Industry

ADVISORY COMMITTEE

An Advisory Committee provides industry feedback on research and community issues; assesses progress against key objectives; and helps target future research directions. Members comprise growers, consultants, agricultural industry and community representatives.

Advisory Committee

Mr Bruce Finney	Australian Cotton Growers Research Association
Dr Don Sands	CSIRO Entomology
Dr Chris Moran	CSIRO Land & Water
Mr Jeff Coutts	Community
Mr Mick Ryan	Cotton Consultants Australia
Dr Graeme Hammer	Dept Primary Industries Qld, APSRU
Mr John Harrison	Amateur Fisherman's Association Northern Territory
Mr Kevin Goss	Murray Darling Basin Commission
Ms Sheila Donaldson	Community

WORKING PARTIES

The CRC has also established discipline-specific working parties to provide coordination, direction and feedback.

ADMINISTRATION

Executive Officer/Business Manager	Ms Kym Orman.
Research Liaison Officer	Ms Nicky Schick.
Administration Assistant	Mrs Lynda George.

The Administration team - Kym Orman, Lynda George and Nicky Schick.

COOPERATIVE LINKAGES

Cooperation among our participant organisations, with our industry stakeholders and with the wider community is an essential attribute for our CRC. The Cotton CRC has continued to engender a collaborative culture and has grown its capacity to interact with a growing range of stakeholder groups. Likewise we maintain strong interactions with international research groups and with the cotton spinning industry in many countries.

Within programs we have a number of projects with multiple organisations involved, and with the establishment of a new Program on managing the whole-farm environment has resulted in expanded engagement with environmental organisations and particularly the Catchment Management Boards in NSW and their equivalent bodies in Qld.

An important mechanism to ensure linkage into the cotton industry are our "Discipline Groups" which provide a regular forum for researchers, extension staff, growers, consultants and other industry groups to discuss research outcomes and identify future priorities. Discipline groups meet at least once each year and cover issues of insect, weed and disease management, farming systems, water and soils, decision support systems and extension. The FUSCOM group (Fusarium Coordinating Committee) is a great example of how all facets of the CRC and industry can cooperate to drive a research and communication program for this threatening disease.

Tremendous advances in the adoption of area-wide management of insect pests, coordinated management of Fusarium and significant improvements in water use efficiency through the Rural Water Use Efficiency Initiative in Qld are all examples of what can achieved through close cooperation of research, extension and industry.

In northern Australia we have maintained direct links with the communities of Katherine and Kununurra and more broadly with many interest groups through widespread distribution of the northern newsletter – Cotton Frontiers. An important step for the prospects of cotton in the NT is a new alliance with the Peanut Company of Australia (PCA) in Katherine where joint farming systems experiments involving cotton and peanuts in rotation are now underway at a commercial scale.

Another landmark outcome is establishment of a coordinated research effort on deep drainage and its consequences in irrigation soils of the northern Murray-Darling basin. This collaboration involves input from a number of CRC participants (University of Sydney, CSIRO, DNRM, NSW Agriculture, APSRU) in association with CRDC, MDBC, LWA. Several projects now underway will contribute greatly to efforts to manage the water balance of whole catchments in the MDB.

Links to other CRC's have been strengthened with existing joint projects with the CRC for Tropical Plant Protection, the CRC for Australian Weed Management; and new research with the Greenhouse Accounting CRC. We recently met with the CRC for Freshwater Ecology to explore joint opportunities for research on biodiversity in rivers and on-farm waters associated with cotton as well as environmental flows.

Our Extension and Education program provides additional foundations for linkage across the CRC and into industry and the wider community. The Cotton CRC's Technology Resource Centre continues to provide effective co-ordination of information flow to industry in the form of printed materials, CD ROMS, computer based decision aids, an email "eNews" service and a comprehensive website (www.cotton.crc.org.au).

Finally our program on Cotton Textile Research has now developed close alliances with over 25 international cotton processors in Japan, South Korea, Thailand and Indonesia seeking to identify their needs as well as how best Australian fibre can meet these needs. This process has been greatly facilitated by Austrade and will feed back to producers and cotton breeders.

INTERNATIONAL LINKAGES

CEO Dr. Gary Fitt has maintained involvement with an International Working Party on the role of transgenic plants in integrated pest management, where he coordinates a section on resistance management for GM plants. During the year the working party, which includes members from Europe, USA, Asia and Africa, organised workshops in Kenya and Brazil focussed on regulatory issues of Bt maize and Bt cotton in those countries.

Many other international linkages are maintained through personal associations of individual scientists. We facilitate this through a research exchange program which supports a number of international exchanges each year. During 2002/2003 we supported visits by:

- Mr Steve Yeates, CSIRO Plant Industry – to visit cotton production regions across the USA, focussing specifically on systems approachs with value to northern Australia.
- Dr Mike Bange, CSIRO Plant Industry to participate as an invited speaker in the 'Integrated Biological Systems Conference' in Texas;
- Dr Alice Del Socorro, UNE to attend the '19th Annual Conference of the International Society of Chemical Ecology' in Hamburg;
- Dirk Richards to participate in the 'International Congress on Irrigation and Drainage' held in Montreal, Canada.

During the year, the Cotton CRC also hosted visits by:

DR. Ravi, K.C. Ph.D Sr. Seminar "Resistance Management Needs for Bt Cotton in India" Scientist Monsanto Research Center Bangalore, 11th April, 2003, ACRI Conference Room, Wee Waa Rd, Narrabri.
Mark Sears. Seminar "Measuring Environmental Effects of Transgenic Corn, the Canadian Experience". 18th November 2002, ACRI Conference Room, Narrabri.
Kendle Wilkinson (CDI) Postdoctoral Fellow with the Centre for the Identification and Diagnostics of Insects and Weeds, School of Life Sciences at The University of Queensland gave a seminar on his project "Genetic Analysis of Heliothis in the Lower Namoi Valley", 7 November 2002, ACRI, Narrabri.
Dr Rob Lind Syngenta Program Manager Insecticide Discovery Jealott's Hill International Research Centre (UK) Seminar: Insecticide Discovery (Modern Techniques), 31st January 2003, Australian Cotton Research Institute - Narrabri
Dr. Peter Ellsworth, IPM specialist with Department of Entomology, University of Arizona. Seminar "Whiteflies in Arizona: An IPM Success Story" 19th December,2002, ACRI Conference Room, Narrabri.
Dr Rebecca Letcher Centre for Resource & Environmental Studies, ANU, 5th November, 2002.
Chinese delegation of farmers and Textiles representatives, 15th January, 2003
Jim Hannan visiting USA scientist, 28th January, 2003.
Charles Willcock AFFA - Industry Partnership Program, 18th February, 2003. Attended a meeting with Cotton CRC.
Pakistan Farming Group visit, 10th April, 2003.
Phil Price and Siwan Lovett, Review of Riparian Guidelines, 6th May, 2003.
Narrabri and Wee Waa High School teachers- Overview of Cotton Research, 22nd July, 2002
Glen Wilson Lead Scientist, Northern Murray-Darling Research Lab, and Mark Southwell Community Scientist. CRC Freshwater Ecology overview research program. 25th October, 2002.
Cotton CRC/ ACRI hosted a student group visit by Students from **Marsden High School**, on April 1, 2003, to discover something of the science underpinning cotton production. The afternoon covered IPM, GM cottons, Breeding and sustainability.

Program One Overview

Growth in northern Australia

Program One Leaders - Geoff Strickland, Agriculture Western Australia and Dr Michael Bange, CSIRO Plant Industry.

Cotton industry expansion in the existing production areas of northern NSW and southern Queensland is constrained by resource availability, particularly water. However a scoping study conducted by Yeates (2001) showed that opportunities exist for expansion of cotton production into new geographic regions in northern Australia. The regions proposed for investigation are in Western Australia (Broome and Kununurra); the Northern Territory (Katherine and Douglas/Daly areas) and north Queensland (Flinders River and others) and provide significant opportunities for growth. The potential area for new cotton, 200,000 ha, would produce a further 1.5 million bales with an export value of $750 million which represents a 50% increase on current production figures. This level of development would generate significant new infrastructure and associated growth in northern Australia and diversify the production base of the Australian cotton industry.

The major Program One objectives are:

- To enhance the prospects for expanding cotton production by researching viable and environmentally responsible cotton production systems for new regions in Western Australia, the Northern Territory and north Queensland.
- To develop solutions to specific regional environmental problems prior to commercial activity.

Highlights and achievements

The year has been very challenging for research in northern Australia. Issues of major importance include the CRDC's decision to terminate funding for projects in northern Australia due to the drought, poor yields at Kununurra in the 2002 season and uncertainties about access to the gin at Kununurra. Another disappointment is the stalling of research activities in north Queensland.

Despite these significant setbacks, some excellent research and new initiatives have occurred. Amongst the important highlights is the expansion of research at Katherine, including the development of important linkages with the Peanut Company of Australia (PCA). PCA grows peanuts in the Katherine region using centre pivot irrigation and sees cotton as a prospective rotation crop. Collaboration with PCA has enabled cotton be grown off the research station and on a larger area.

After a 3-year hiatus, field trials have recommenced at Shamrock Station, south of Broome, in collaboration with Western Agricultural Industries (WAI). Land tenure issues associated with Native Title and a series of inconclusive court decisions have prevented field trials in recent years. Although issues remain, a way forward to enable small plot evaluations of Bollgard II® and Roundup Ready® cotton has been identified.

Rowena Eastick completed and published a landmark report entitled "Evaluation of the potential weediness of transgenic cotton in northern Australia". The 200-page report provides unique technical information that dispels many of the concerns about weediness of GM cotton in northern Australia.

Funded projects in Program One include:

Program One researchers at a workshop in Darwin in November 2002. Back Row: Rowina Eastick, John Moulden, Steve Yeates, Bruce Sawyer, Dr Gary Fitt, Peter McCosker, Dr Brian Duggan, Dr Michael Bange, and Mike Kahl. Frount Row Geoff Strickland, Ali Duale, Dr Amanda Annells, Dr Andrew Dougall, Stewart Addison, Dr Colin Martin, Dr Richard Seqeira, Nerylie Gaff and Dick Steele.

1. Viable and environmentally responsible cotton production systems for northern Australia: Scoping Studies and Research Liaison / Coordination Officer (Darwin)
2. Cover crops and rotations for sustainable cotton cropping systems on light textured soils in NW Australia (Broome)
3. Preliminary evaluation of Bollgard II and Roundup Ready cotton in a dry season environment in the west Kimberley (Broome)
4. Pesticide residue sampling and analysis (Kununurra)
5. Insect dynamics of the cotton ecosystem in the Northern Territory (Katherine)
6. Pest management for transgenic cotton in far north Queensland (on hold)
7. Agronomy and farming systems for cotton production in northern Queensland (on hold)
8. Scoping study - north Queensland

Other significant highlights are as follows:

- A workshop involving Program One cotton researchers was held in Darwin in November 2002. The workshop was an important forum for information exchange and coordination of research activities. The majority of the workshop was devoted to developing a preliminary framework for a Bollgard II® production package for northern Australia, tentatively named "Norpak". The workshop also defined a 'best bet' management approach to cover all future research activities.
- CRC staff have contributed to meetings with environmental groups in Katherine and Broome to discuss their concerns about prospects for cotton growing.
- University of Western Australia student Tanya Gordon completed the requirements of a summer scholarship with a project titled 'Evaluating wet season cover crops as potential nurseries for dry season insects in the Ord River Irrigation Area'.
- Rowena Eastick's report 'Potential weediness of transgenic cotton in northern Australia' was published by the NT government.
- University of Queensland student Andrew Davies completed the fieldwork for his PhD thesis on the ecology of Trichogramma spp. in the Ord River Irrigation Area.
- Several Program One researchers including Amanda Annells, Steve Yeates, Rowena Eastick, Andrew Davies and Geoff Strickland attended the World Cotton Research Conference-3 in Cape Town, South Africa, and presented papers.
- Development of a specific component of the Cotton CRC's website to cover northern activities.

Dr Michael Bange, Dr Gary Fitt and Dr Brian Duggan inspecting cotton trials after the Program One Research Workshop in Darwin November 2002.

A half centre pivot of cotton near Katherine with lablab refuge strips being inspected by Andrew Dougall. The other pivots are planted with peanuts. This is at the Peanut Company of Australia's farm at Katherine.

- A survey of volunteer plants along transport routes north of 22 degrees S was completed by Grant Roberts & Tracey Farrell. The survey showed that after 12 years of fuzzy cotton seed being transported by road from Emerald to the Atherton Tablelands there are very few volunteer cotton plants established on roadsides. In addition while populations do establish on dairy farms their ability to persist and produce new viable seedlings is low. Over the 12 years they have failed to spread or exhibit weedy characteristics. Following this it is unlikely that the continued transport and feeding of fuzzy seed will pose significant risk of volunteer cotton developing into a weed of importance on either the transport routes or the Atherton dairy farms.

Linkages and Collaboration

CRDC funds a number of projects of direct relevance to the northern areas and there are valuable linkages with several projects operating in NSW and southern QLD in the south. Important CRDC projects include:

- Development of sustainable pest management practices for Bollgard II® production in the Kimberley (Agriculture Western Australia).
- Ecology of Trichogramma egg parasites in the Ord River Irrigation Area and their role in cotton IPM (University of Queensland).
- Development of agronomic management options for dry season cotton production in northwestern Australia (CSIRO Plant Industry).
- Investigation of cotton growing at different sites under different farming systems in the Northern Territory (NTDBIRD).

Other research activities that are integrated with projects funded by the Cotton CRC or CRDC include:

- Ecological studies of Helicoverpa populations related to the successful implementation of IPM systems based on Bt transgenic cottons. (CSIRO Entomology).
- Pesticide resistance in cotton aphid and twospotted mite.

Rowina Eastwick collecting data for her report on the potential weediness of transgenic cotton in northern Australia.

(NSW Agriculture).
- Resistance management in Australian cotton: conventional insecticides and transgenic cottons. (NSW Agriculture).
- Breeding improved cotton varieties. (CSIRO Plant Industry).
- Predicting and enhancing cotton compensation following pest damage. (CSIRO Plant Industry).
- Continued development and field evaluation of micro-computer cotton management packages. (CSIRO Plant Industry).
- The impact of temperature extremes on cotton performance. (CSIRO Plant Industry).
- Ecological assessment in northern Australia of transgenic cotton expressing the CryIA(c) and CryIIA delta-endotoxins from Bacillus thuringiensis. (CSIRO Plant Industry).

Project Summaries

PROJECT NUMBER.: **1.1.01 AC**

PROJECT TITLE: **Viable and environmentally responsible cotton production systems for northern Australia: Scoping Studies and Research Liason/Coordination.**

STAFF:
Stephen Yeates, CSIRO Plant Industry, Darwin, NT.

AIMS & MILESTONES:

Assist in the investigation and development of viable and environmentally responsible production systems for new regions in Western Australia, the Northern Territory and north Queensland by:

1. Facilitating actions following the publishing of the scoping report.

2. Providing scientific support to the CEO, Program Leaders, researchers and to provide some supervision of projects located in northern Australia.

By December 2005 our research will have assessed the feasibility for economically and environmentally sustainable cotton production at two sites in northern Australia (Ord River and Katherine-Daly Basin) to a point where a decision on commercial development can be made. Specifically this project will assist to develop an agronomic package and incorporate this package with the broader issues critical to sustainable irrigation development such as land and water resource allocation, economic analysis and environmental impact.

OVERVIEW & OUTCOMES:
There is considerable commercial and government interest in utilising some of the vast water and land resources of northern Australia for irrigated agriculture, where cotton could be a significant crop.

A focus this year has been to implement the 5 year R&D plans for the Kimberley, NT and north Qld that incorporate both production research and address issues of land and water resources, community consultation and environmental impact.

Communication has been maintained with relevant research and other bodies in northern Australia, while coordination of specific research activities across northern Australia has included agronomic measurement of off paddock nutrient, water and chemical movement.

The project has been active in the review and planning of all CRC projects in northern Australia. Specifically this project will assist to develop an agronomic package and incorporate this package with the broader issues critical to sustainable irrigation development such as land and water resource allocation, economic analysis and environmental impact.

Monitoring water use at Kununurra.

Program Leader Geoff Strickland, Agriculture Western Australia inspecting Kununurra trials.

John Moulden (Ag WA) measuring water quality at the tail drain from the 'best bet' cotton field near Kununurra. This is a CRC funded initiative.

PROJECT NUMBER: **1.2.03 AC**

PROJECT TITLE: **Preliminary evaluation of Bollgard II® and Roundup Ready® cotton in a dry season environment in the west Kimberley.**

STAFF:
Geoff Strickland, Department of Agriculture, Perth, WA.
Stephen Yeates, CSIRO Plant Industry, Dawrin, NT.

AIMS & MILESTONES:
The aim of the project is to undertake preliminary studies to assess the performance of Bollgard II® and Roundup Ready® cotton varieties in the west Kimberley. These new transgenic technologies have not been assessed in the area south of Broome.

In summary, the aims of the project are:

* to assess the efficacy of Bollgard II® varieties in controlling lepidopteran pests
* to benchmark the yield and quality of Bollgard II® and Roundup Ready® varieties to previously assessed INGARD® varieties
* to assess the performance of Roundup Ready® varieties in the west Kimberley dry season
* benchmark the Bt succeptibility of local *H. armigera*.
* to assess refuge crop options for pre-emptive resistance management

OVERVIEW & OUTCOMES
The Kimberley region of Western Australia is one of the most prospective for a significant expansion of the Australian cotton industry into northern Australia. The area under focus in this project is the west Kimberley region, south–east of Broome. The region possesses vast tracks of red sandy soils suitable for trickle irrigation, but currently used for low productivity pastoral activities. Ground water reserves are extensive and preliminary studies suggest sufficient reserves in the Canning Basin aquifer to irrigate 30,000 ha of cotton annually on a sustainable basis. Other aquifers exist and, in the longer term, there is scope to harvest surface water from the Fitzroy River catchment.

This project aims to benchmark the performance of Bollgard II® and Roundup Ready® cotton in the west Kimberley. These products have not been assessed in the region. In addition, almost nothing is known of pest abundance and significance in the area. The resistance status and seasonal movements of pests and beneficials is also un-researched. Benchmarking will enable the tracking of changes in pest status as commercial activity commences. However, most importantly it will provide the information required to develop sustainable pest management systems for the region and pre-emptively deal with issues, such as resistance, which have challenged existing production areas.

Permits for the trials from Pastoral Lands Board and Water and Rivers Commission were received on the 25th June 2003 and the trials were planted that day. The total crop area is 1.4 ha.

The Bollgard II and Roundup Ready cotton trials in the west Kimberly, near Broome, planted on the 25th June 2003.

The Bollgard II best practice block funded by the Cotton CRC at Kununurra. This crop went on to yield 8.6 bales/ ha.

PROJECT NUMBER: **1.3.01 AC**

PROJECT TITLE: **Insect dynamics of cotton ecosystem in Northern Territory**

STAFF:

Dr Andrew Ward, DBIRD, Katherine, NT.

AIMS & MILESTONES:

The primary aim of the project is to benchmark the ecology of the key pests and beneficial insects that are likely to impact on a future cotton industry in the Katherine area, so that IPM systems can be tailored for the region.
The aims of the project are:

- to monitor the seasonal abundance of lepidopteran pests (*Helicoverpa armigera, H. punctigera, Spodoptera litura* and *Pectinophora gossypiella* – pink bollworm). Pheromone traps at 10 sites, both crop and bush, will be serviced weekly.
- to develop a pre-emptive Bt resistance management plan based on local population dynamics and the role of alternative crops in producing non-Bt selected moths
- to assess the insecticide resistance status of *H. armigera* and *Aphis gossypii* and implement pre-emptive resistance management strategies for Bt in *H. armigera*, and to all chemical groups in A. gossypii.
- to categorise the beneficial insect fauna in cotton in the Katherine and Douglas-Daly regions and provide estimates of their relative beneficial status.
- to monitor the seasonal activity of *Trichogramma* on cotton and other local crops

OVERVIEW & OUTCOMES:

Observations made in the 2001 and 2002 seasons suggest that the major insect problems at Katherine are *Helicoverpa armigera* and a range of sucking insects including mirids, red banded shield bugs and green vegetable bugs. *Spodoptera litura* also have the potential to cause sporadic damage early in the season but seem to "disappear" as the season progresses. Aphids were also a problem in 2002 but in most fields were managed effectively by beneficial insect populations.

With the move to the use of Bollgard II varieties, *Helicoverpa* are likely to become less of a problem, although resistance management strategies will be required. As a result, a major focus of the research program has become sucking insects. A broad aim of the research being conducted at Katherine Research Station is to develop a cotton production system with minimal reliance on insecticides. To this end we have researched the use of trap and companion crops which might be used to reduce pest pressure in cotton, and the development of action thresholds. The results to date suggest that populations of sucking insects up to at least 1.5/m can be tolerated up to first flower. However, after first flower populations of 0.5 /m appear to result in significant yield loss.

Trials conducted in both 2001 and 2002 have examined a number of companion crops with the view of selecting a crop that is attractive to sucking insects, *Helicoverpa* and beneficials. Crops that have been examined include lablab, niger, chickpea, kenaf, pigeon pea and sesame. At this stage it appears the best all round option is lablab, which was the most attractive crop to *Helicoverpa* and sucking insects and was also reasonably attractive to beneficial insects.

Beneficial insects have been observed to have a significant impact on the pest populations in Katherine. This has been particularly evident in aphids with hover fly larvae successfully controlling large outbreaks. Parasitism of *Helicoverpa* eggs as a result of *Trichogramma pretiosum* has been evident in the early part of the season but quickly falls away to zero by early June. Other parasites such as *Microplitis* and Tachinids are also evident late in the season. However, parasitism is significant in terms of total pest management.

A network of pheromone traps has been operating for the last 2 years at 8 sites to examine the seasonal abundance of the major lepidopterous pests likely to impact on any future cotton industry in Katherine. The network has shown highest catches of both *Spodoptera litura* and *Pectinophora gossypiella* during the wet season, thus supporting the basis for a move to dry season production. *Helicoverpa armigera* populations were the reverse with the highest populations being recorded during the dry season while the cotton was growing. Very few *Helicoverpa punctigera* were trapped at any of the 8 sites where monitoring took place. This was supported by the use of the diagonistic kit Lepton which demonstrated that most *Helicoverpa* eggs were *H. armigera*.

Insecticide resistance testing has demonstrated that resistance to synthetic pesticides is generally low. This is not surprising due to the limited area of crops in the Katherine area. *Helicoverpa* from Katherine had higher tolerance to Bt than the Narrabri susceptible strain, but is more susceptible than *Helicoverpa* from Kununurra. In both cases the strains were within the natural levels of Bt tolerance found among populations from around Australia.

Program Two Overview

Innovative Technologies

Program Two Leaders Dr Steve Allen Cotton Seed Distributors and Associate Professor Peter Gregg, University of New England.

Commercial cotton production relies on a number of chemical inputs for high levels of production. While progress has been made in adoption of transgenic plants, Integrated Pest Management (IPM) and Best Management Practice (BMP), there remains an imperative to seek alternative management tools which minimise dependence on disruptive pesticides. This program reflects the need for innovative solutions to pest, weed and disease problems and the need for new tools to remediate or monitor environmental impacts. The program also includes fundamental work on the molecular genetics of cotton, which will aid in breeding for various characteristics including pest and disease resistance and fibre quality. Overall the program aims to research and develop innovative technologies which provide an improved range of options for environmentally acceptable crop management and bioremediation.

Specific objectives for projects include:

- To rigorously evaluate the efficacy and environmental impacts of new transgenic plants.
- To develop and evaluate the use of attractants and repellents for *Helicoverpa spp*.
- To identify and evaluate effective biocontrol agents for soil-borne pathogens of cotton.
- To investigate the use of 'biofumigation' and 'systemic induced resistance' for improving the efficacy of disease control strategies.
- To develop more effective and user-friendly diagnostic kits for rapid detection of pests and diseases in plant tissues and in soil, and for pesticide residues and pest resistance.
- To investigate bioremediation techniques for pesticide contamination on cotton farms.

The utilisation of new technologies emerging from this program will be developed in Program three, in the context of sustainable farming systems.

Highlights and Achievements

*Consistent high efficacy of Bollgard II cotton varieties producing both CryAc & Cry2Ab protein has been demonstrated. The insecticidal proteins produced within these plants provide significantly improved protection against specific insect pests. The concentration and persistence of the CryAc & Cry2Ab proteins over time has been characterised.

*A management strategy for Bollgard II cotton has been developed in consultation with industry and accepted. Such a strategy is essential for minimising the chance development of insect resistance and consequent failure of the technology.

* Semiochemicals are 'signalling' compounds that are produced by some plants and either attract or repel potential insect pests. The efficacy of improved Helicoverpa attractants has been demonstrated in large scale trials. Two potential deterrent chemical compounds have been identified from a plant 'X'.

*Bioremediation involves the use of a biological system to denature or degrade unwanted or harmful pesticide residues. A signel gene encoding an enzyme that degrades endosulfan sulphate and both isomers

of endosulfan, has been isolated from a naturally-occuring bacterium and cloned.
* Laboratory cultures of Earias huegeliana have been established and pheromones have been collected and evaluated in the field at Kununurra. A laboratory culture of cotton tipworm has also been established. The objective of these studies is to develop biological mechanisms to disrupt normal insect behavious.
* DNA has been successfully delivered to H. armigera embryos by microinjection. This is the first step in the development of techniques to 'silence' specific genes in the pest.
* Fusarium diagnostic tools have been developed and used to detect the Fusarium wilt pathogen in bulk cottonseed for export. These sensitive molecular tools have also been developed to characterise new outbreaks of the disease and assist in determining the efficacy of various agronomic treatments that are being evaluated for disease control.
* Small scale field trials have demonstrated potential benefits of Induced Resistance to artificially 'turn on' the plants own natural defence system and provide improved resistance to plant pathogens.
* Biofumigation occurs when fungitoxic compounds are naturally released into the soil from the roots and/or degrading plant residues of specific green manure crops. The benefits of biofumigation for black root rot control have been demonstrated.

Project Summaries

PROJECT NUMBER: **2.1.01 AC**

PROJECT TITLE: **Efficacy and field performance of new transgenic cottons**

STAFF:

Dr Geoff Baker, CSIRO Entomology, Canberra ACT.
Dr Gary Fitt, Australian Cotton CRC, Narrabri NSW
Cheryl Mares, CSIRO Entomology Narrabri NSW
Karen Olsen, CSIRO Entomology, Canberra ACT
Leanne Scott, CSIRO Entomology, Canberra ACT.

AIMS & MILESTONES

i) assess the efficacy of field grown cotton varieties expressing the Cry IAc and Cry2Ab insecticidal proteins from *Bacillus thuringiensis*, using a variety of techniques
ii) quantify changes in the concentrations of Bt in plant samples collected from field grown plants, correlate with seasonal changes in field performance
iii) to study the effects of environmental factors on the performance of transgenic Bt cotton plants under controlled, insecticide-free conditions.
iv) contribute to the development of resistance management strategies for two gene Bt cottons

1. Finalise all field evaluations of new lines of Bt transformed varieties expressing Cry IAc and Cry2Ab proteins.

2. Finalise all biochemical and ELISA assays of plant samples from field experiments. In particular to complete ELISAs of Cry2Ab protein in field grown plants.

3. Finalise resistance management strategy for CryIAc/ Cry2Ab cottons in Australia based on studies of efficacy, Bt protein dynamics and performance of refuge options. Objective to be achieved in conjunction with TIMS, Monsanto and other researchers.

4. Complete data analysis, produce final reports and a series of publications.

OVERVIEW & OUTCOMES

INGARD cotton varieties expressing the CryIAc gene have brought substantial benefits to Australian cotton production through a 50% reduction in pesticide requirement. Considerable research has underpinned the resistance management strategy which accompanies INGARD cotton and the use of this technology in IPM systems.

In the 2002/2003 season we have completed field evaluation of the CryIAc/ Cry2Ab combination of proteins, now registered as Bollgard II. Field evaluations with several varietal backgrounds has demonstrated considerably higher and more consistent efficacy of the two-gene combination against *Helicoverpa spp*, than seen with INGARD.

We have also characterised protein expression patterns using a quantitative ELISA. These demonstrate variability in Cry IAc levels among plant parts and varieties with lower concentration in squares than in leaves. By contrast Cry 2Ab levels are considerably higher in squares, the most vulnerable structures on the cotton plant. Interactions of the Bt proteins with other secondary plant products remain unclear. A series of lines derived from a cross of an INGARD and high tannin variety show negative correlations between concentrations of tannin and Bt during plant development, but there is little support for a causal association.

Importantly the resistance management strategy for the commercial use of Bollgard II cotton has now been finalised. On the basis of its enhanced efficacy, the strategy allows removal of the 30% cap previously applied to INGARD varieties, although all other aspects (on-farm refuges, planting window, crop residue destruction) remain the same as for INGARD. This guarantees that Australia maintains a highly conservative strategy likely to safeguard the clear environmental and production benefits of Bt cotton for a considerable period.

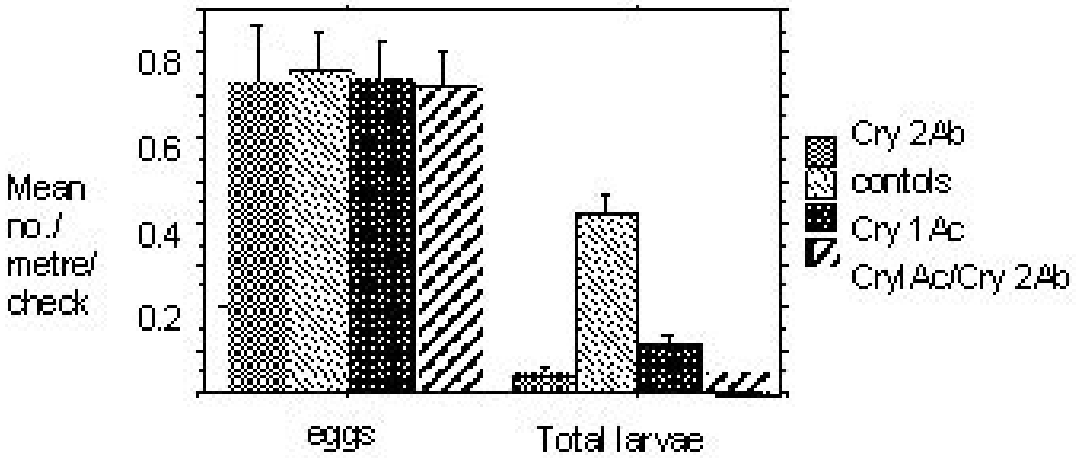
Leanne Olsen caging neonates on cotton plants.

Caging neonates on whole cotton plants.

Cheryl Mares running elisa testing for Bt expression.

Judy Nobilo bug checking Bt cotton.

Abundance of *Helicoverpa* eggs and larvae on replicated field plots of different transgene combinations and control varieties.



PROJECT NUMBER: **2.2.03 AC**

PROJECT TITLE: **Semiochemical approaches to control Helicoverpa spp.**

STAFF:
Dr Alice P. Del Socorro, UNE, Armidale, NSW
Dr Peter C. Gregg, UNE, Armidale, NSW
Richard Tennant, UNE, Armidale, NSW
Dan Alter, UNE, Armidale NSW
Dr Chris Moore, QDPI, Brisbane, QLD.

AIMS AND MILESTONES:
1. To develop improved attractants based on plant volatiles chemicals, for adult *Helicoverpa spp*., especially females.
2. To conduct large-scale field trials of attract-and-kill techniques using female attractants and/or pheromones.

1. Continue to improve female attractants.
2. Repeat large-scale field trial using modified formulations.
3. Conclude commercial arrangements, if warranted.

OVERVIEW & OUTCOMES:
This project builds on the work of a previous CRC project to develop plant volatile based attractants for the adult (moth) stage of the key pests of cotton, *Helicoverpa spp*. We obtained a permit in October 2002 from the Australian Pesticide and Veterinary Medicine Products Registration Authority to conduct large-scale field trials of moth attractants on various crops including cotton. The first of these trials was conducted on a 42-ha irrigated conventional cotton. About 1.5% of the field (11 rows x 600m long) was sprayed three times with attractants containing 0.5% methomyl between November 2002 and January 2003. An adjacent unsprayed field of similar area was used as the control. In the treated field, we estimated to have killed about 30, 000 *Helicoverpa* moths and prevented the laying of about 13 million eggs following the first spray. A comparison of the local treated and adjacent control fields showed that there were consistently fewer *Helicoverpa* in the treated than the control field following each attractant application. Likewise, a comparison of the treated district (~200 ha of cotton) and the control district (~250 of cotton 6-8 km away) showed similar reduction in Helicoverpa numbers in the treated region, suggesting possible area-wide impact of our attractants. More expanded field trials will be conducted next season to see if similar area-wide impacts are repeatable.

Another trial on a 9-ha Bollgard II cotton crop was also conducted at Kununurra, W.A., using four types of insecticides. Only the methomyl-treated attractant killed significant numbers of *Helicoverpa* moths. Preliminary trials in Goondiwindi to determine the effects of our attractants on beneficials, showed that there might be weak attraction to ladybirds, but none to lacewings, wasps, spiders and some other beneficial groups. In a large scale field trial there were no significant effects of the attractant on most groups of beneficials, although we observed that there were significantly fewer ants in the treated field compared to the control. We will continue to monitor the effects of our attractants on beneficials in future field trials.

We are well advanced with patenting and negotiations with a potential commercial partner for the development and eventual commercial release of moth attractants.

PROJECT NUMBER: **2.2.04 AC**

PROJECT TITLE:**Bioremediation enzymes for endosulfan sulfate.**

STAFF:
Dr John Oakeshott, CSIRO Entomology, Canberra ACT
Dr Irene Horne, CSIRO Entomology, Canberra ACT
Kahli Weir, CSIRO Entomology, Canberra ACT
Dr Anthony Zera, University of Nebraska, USA.

AIMS AND MILESTONES:
To isolate a gene enzyme system capable of single step detoxification of endosulfan sulfate and to evaluate its efficacy in cleaning up contaminated run-off water.

Year 1 - Isolation of endosulfan sulfate degrading microorganism
Year 2 - Characterisation of endosulfan sulfate degrading enzyme
Year 3 - Cloning and expression of the gene encoding the endosulfan sulfate degrading enzyme and field evaluation of these enzyme.

OVERVIEW & OUTCOMES:
This project was concerned with the isolation of an enzyme for the degradation of endosulfan sulfate, a toxic by-product of the insecticide, endosulfan, which forms in the soil. The project is part of a much larger study undertaken by CSIRO Entomology and commercial partner, Orica Australia Pty Ltd, in conjunction with Horticulture Australia Limited, to develop remediation technologies for pesticide residues in the environment, spent dip liquor, the wash-down from spray equipment and potentially on horticultural commodities.

A bacterial strain was isolated with the ability to degrade endosulfan sulfate, as well as endosulfan itself. The gene encoding the enzyme responsible for this activity was sequenced and the enzyme characterised biochemically. Interestingly, the enzyme was a monooxygenase similar to an enzyme that has been used in the desulfurisation of fossil fuels. The monooxygenase requires the presence of expensive cofactors for activity in the laboratory, and its use for remediation in the field will require the identification of less expensive alternatives.

The outcome sought is environmentally benign natural chemical tools for the management of cotton pests. This will contribute to a more ecologically sound and cost effective approach to the management of pests such as Helicoverpa spp. enabling the cotton industry to achieve sustainability, profitability, international competitiveness and reduced dependence on synthetic insecticides.

PROJECT NUMBER: **2.2.06 AC**

PROJECT TITLE: **Managing Helicoverpa spp on Cotton with semiochemicals**.

STAFF:
Dr Chris Moore, QDPI, Brisbane, QLD
Dr Robert Mensah, NSW Agriculture, Narrabri NSW
Dr Ertong Wang, QDPI, Brisbane, QLD
Dr Ho T. Dang, NSW Agriculture, Narrabri NSW.

AIMS & MILESTONES:
The project aims to identify chemical components of the organ surfaces of plants, including cotton genotypes and trap and refuge crops, that influence acceptance or rejection by adult and larval heliothis, with a view to exploiting these bioactive compounds as stimulants and repellents/deterrents against *Helicoverpa spp*. on cotton.

Current milestones relate to the bioassay of plant extracts in both laboratory and mesh house in order to direct the isolation of active compounds, together with similar confirmatory bioassays of isolated candidate compounds followed by small-plot field trials.

OVERVIEW & OUTCOMES:
The Australian cotton industry has been heavily dependent on the use of synthetic insecticides for insect control, especially for *Helicoverpa* spp. While major reductions have been achieved through IPM & transgenic cotton, other alternatives are still required.

This project seeks to identify chemicals which do not kill insects, but demonstrate stimulant or deterrent/repellent activity towards *Helicoverpa* spp on cotton, and therefore show behaviour modifying properties which might be exploited. Semiochemicals which are extracted from plants may provide environmental friendly components for integrated pest management components.

Two major components of an extract from a leguminous plant (plant X) have been found to be deterrent to *Helicoverpa armigera* female moths. The chemical structures of these components have been elucidated. They will be purified and formulated for field tests in the near future.

Other sources of feeding stimulant/oviposition attractant have been identified from various refuge crops and cotton genotypes. The feeding stimulant(s) will be isolated and used to improve the efficacy of various control agents particularly biological pesticides (Bt and NPV) and also new insecticides which have to be ingested to be effective. The oviposition attractants could be used in IPM to improve the performance of trap crops, divert egg-lay on cotton and incorporated in attract-and-kill control strategies.

Dr Chris Moore in the foreground and Dr Ertong Wang in the background with the HPLC instrument funded by the Cotton CRC for the project.

PROJECT NUMBER: **2.2.07 AC**

PROJECT TITLE: **Pheromones for occasional pests of cotton**

STAFF:
Samuel Lowor, PhD student, UNE, Armidale, NSW
A/Prof. Peter Gregg, UNE, Armidale, NSW
Dr Alice Del Socorro, UNE, Armidale, NSW
Dr Chris Moore, QDPI, Brisbane, NSW
Dan Alter, UNE, Armidale, NSW
George Henderson, UNE, Armidale, NSW.

AIMS & MILESTONES:
1) To conduct further behavioural observations of male *Agrotis infusa* moths to female gland extracts in wind tunnel.
2) Optimise pheromone blends based on analyses done

for Agrotis to be used in wind tunnel and further field evaluation.
3) Establish laboratory cultures of *Earias huegeliana* and cotton tip worm for possible pheromone collection and identification

OVERVIEW & OUTCOMES:
Pheromones for the key pests of cotton, *Helicoverpa armigera* and *H. punctigera*, have been widely used in research and for monitoring these pests. There is, however, very little information about pheromones of other cotton pests. This particularly applies to occasional pest species such as cutworms (*Agrotis spp.*) It is currently difficult to forecast the abundance of these species. Considerable damage may occur before growers are aware of the problem. Other pests, such as the rough bollworms (*Earias spp.*), are likely to become more important with the expansion of the cotton industry to new areas, especially in northern Australia. Pheromones have been identified for some species in this genus in south Asia and Africa, and successfully trialed in mating disruption studies. There was, however, no information on the pheromones of the dominant Australian species, *E. huegeliana*. For this species, gland and air collections of pheromones were done and analysed by gas chromatography/mass spectroscopy (GC-MS). Results indicated a four gland component as opposed to three in the air collection. Blends of the components so far tried in with preliminary field work indicates catches of sometimes up to 50 plus in a day. We anticipate being able to produce these lures for E. huegeliana at UNE in sufficient quantities after we have optimised the blend for wider trials by growers and consultants at the end of the project.

PhD Student Samuel Lowor

PROJECT NUMBER: **2.2.08 AC**

PROJECT TITLE: **Gene silencing technologies to control Helicoverpa armigera**

STAFF:
Derek Collinge, PhD Student, Australian National University.
Dr Steven Whyard, CSIRO Plant Industry, Canberra ACT
Dr Carolyn Behm, ANU, Canberra, ACT.

AIMS & MILESTONES:
Development of DNA delivery methods for *Helicoverpa armigera*

OVERVIEW & OUTCOMES:
New methods to protect cotton plants from insect pests must be sought to counter the growing incidence of resistance to our existing pesticides. With increasing public concern about environmental contamination by chemical pesticides, novel biological methods of pest control are of particular interest. A recent breakthrough in the field of molecular biology, known as RNA interference (RNAi), shows tremendous promise in developing many new approaches to the biological control of insect pests. RNAi is a process by which addition of double-stranded RNA (dsRNA) into a target species results in highly specific gene silencing. By reducing the expression of any gene essential for the target pest's growth and development, RNAi could be used as an effective method of protecting crop plants from insect damage or of controlling the propagation of the pest insects themselves. The purpose of the PhD student project is to assess RNAi-based approaches for the control of the major insect pest of Australia's crop agriculture, the cotton bollworm *Helicoverpa armigera*. In addition to assessing the efficacy of RNAi, the project will attempt to develop a genetic transformation system for this pest species. The development of a genetic transformation system for *Helicoverpa* will provide an extremely useful and versatile molecular biology tool for identification of genes essential to the species' development and reproduction. Ultimately, it is expected that the project will provide new solutions for the control of Australia's most serious insect pest.

PhD Student Derek Collinge

PROJECT NUMBER: **2.2.12 AC**

PROJECT TITLE: **Molecular diagnosis of fusarium wilt of cotton in Australia**

STAFF:
Lisa Gulino, PhD Student, CRCTPP/AC CRC.
Dr Stephen Allen, CSD, Narrabri, NSW
Dr Suzy Bentley,CRCTPP, Toowoomba, QLD
Emma George, QDPI/CRCTPP, Toowoomba, QLD
Dr Joe Kochman, QDPI, Toowoomba, QLD
Wayne O'Neill, QDPI, Toowoomba, QLD
Linda Smith, QDPI, Toowoomba, QLD
Linda Swan, QDPI, Toowoomba, QLD.

AIMS & MILESTONES:
Finalise the development and validation of the Fov DNA diagnostic test.

- Develop protocols for DNA purification and PCR amplification from different sample types, including cotton plant material, soil, cottonseed and water.
- Develop and evaluate different sampling strategies for detecting Fov using the DNA diagnostic test.
- Validate the application of the Fov DNA diagnostic to detection and identification of Fov in infected plant tissue, infested soil and contaminated seed.
- Thoroughly road-test the PCR-based diagnostic test in different situations.
- Transfer the diagnostic test to the relevant commercial laboratory.

OVERVIEW & OUTCOMES
A rapid and accurate DNA diagnostic test specific for the Australian strains of *F. oxysporum* f.sp. *vasinfectum* has been developed and validation of the test is in progress.
This DNA diagnostic test will enable:

- More rapid and accurate diagnosis of outbreaks of fusarium wilt directly from infected plants, infested soil, contaminated seed and water
- Rapid identification of new strains of Fov either introduced from overseas or arising through local evolution
- Improved capability to monitor disease distribution
- The ability to screen cotton seed for the presence of the pathogen, to ensure 'clean' seed prior to planting
- The ability to screen fields for the presence of Fov prior to planting, allowing identification of fusarium wilt free planting sites
- The ability to determine the effect of biological control agents and/or other disease management practices on pathogen inoculum
- Information on the epidemiology and ecology of fusarium wilt, which may lead to the development of better control strategies in the future

Program Three Overview

Sustainable Farming Systems.

Program Three Leaders - Dr Lewis Wilson CSIRO Plant Industry and Dr Inakwu Odeh University of Sydney.

The sustainability of cotton production depends on the development of strategies that encourage efficient use of resources, minimise inputs and impact on the environment and yet remain profitable. Key threats facing the industry include water-use efficiency, management of pests, weeds and diseases, soil management, salinity risks and off-farm movement of inputs.

Program three is addressing these threats through a portfolio of research aimed at optimising the use of pesticides, fertilizers and water thereby reducing the opportunity for off-farm movement. Our research is providing the fundamental understanding of crop growth and development and interactions with the soil that is the basis for such improvements in management. Issues such as integrated management of insects, weeds and diseases and crop nutritional management, soil health and water use efficiency, are emphasised. Several research projects are aiming to better understand where beneficial populations originate and the movement between cotton and 'natural' components of the landscape as well as understanding the value of different predator groups in controlling pests.

While a considerable portion of the program maintains a discipline focus, emphasis is also placed on a farming systems approach. A farming systems scientist and several projects are addressing the challenges of understanding the interactions between elements of the systems, for instance the interactions between pest, water and nutritional management. This ensures outcomes are effectively integrated into the broader cotton agroecosystem to enhance both sustainability and profitability.

Highlights and Achievements

There has been significant progress in improving the management of weeds and diseases. This is highlighted by the development of WEEDpak and DISEASEpak, two comprehensive information sources that synthesise years of research into, readily accessible documents. The Pest and Beneficial Guide and IPM Guidelines for insect pests, which form the backbone of ENTOpak are also currently in revision with the release of new versions intended for late 2003. Silver leaf whitefly (*Bemisia tabaci B-biotype*) became a major problem in Central Queensland during 2001-02. Significant progress has been made toward improving understanding of the ecology of this pest and factors influencing the development of outbreaks. A number of extension documents were also developed, and effective implementation of the approaches outlines saw the whitefly problem managed successfully in 2002-03.

The development of cotton production in new regions of southern NSW (eg. Lachlan Valley) has increased demand for research into IPM, area wide management (AWM), insect resistance management (IRM) and generic soil research. The Cotton CRC, CRDC and GRDC have funded a research and extension team at Griffith. This team has contributed to improvements in the IPM system through research on trap crops, the

role of weeds as pest hosts, the development of Area Wide Management approaches and an adoption of an insecticide resistance management strategy. A soil baseline study has recently been completed for the southern region.

Cotton is currently threatened by a number of diseases, including the devastating Fusarium Wilt, as well as other economically significant diseases such as Black Root Rot and Verticillium Wilt. Screening for resistance to Fusarium is showing useful levels of tolerance in selected cotton genotypes. Progress has also been made toward development of molecular techniques to allow fast accurate identification of the disease. Research has also begun to identify the role of weeds and rotation crops in influencing inoculum levels in cotton fields.

The Cotton CRC has an active soil ecology or soil function group and suite of coordinated projects. Regional studies of soil physical, chemical and hydraulic properties have continued, and provide the most comprehensive soils database available for any rural industry. Increasingly models are being used to combine a range of soil properties in order to understand and predict salinisation, deep drainage, acidification and carbon dynamics. New projects in the soil health area involve: 1) investigation of the interaction between the soil microbial diversity and the incidence of root diseases such as black root rot; and 2) development of a soil function model to enable sustained and improved cotton production systems. Cotton nutrition is assuming a greater significance, especially in areas with a long history of cotton production or on more marginal soils. The advent of Bollgard® II with the potential for high early season fruit retention, resulting in imbalances between the demand for nutrients and the plant's capacity to supply them is also looming as a management challenge. Recent research has begun to address these issues, with emphasis on the management of sodicity, potassium and phosphorous.

Water use remains a key issue for cotton production due to the combined pressures of competition with other uses (i.e. environmental flows) and the effects of drought. A water-use efficiency calculator has been developed to help growers measure their water use and identify areas of loss or inefficiency. This has been evaluated by growers and Industry Development Officers and modifications to improve usability are underway. HydroLOGIC, a software package to assist with scheduling irrigation requirements and to ask 'what if' questions about delaying or omitting irrigations is in the final stages of development and should be available next cotton season.

Farming systems research continues to provide a broader understanding of the outcome of manipulating elements of the production system. Outcome from experiments involving tillage and rotation combinations indicating that cotton – wheat and cotton-wheat legume rotations have advantages in terms of nutrition, soil function and long-term profitability. Progress has also been made in overcoming problems with the retained stubble systems, particularly in taking advantage of increased infiltration but avoiding waterlogging. Experiments have also been designed to investigate the true effects of some of the practices developed by industry. Recently this included the use of late season plant growth regulators to make plants mature earlier and be less attractive to pests. The results of experiments exploring this strategy have called into question the validity of this approach and emphasised other aspects of the system that contribute far more to early maturity.

Progress toward Milestones

There has been solid progress toward meeting the milestones for years 3, 4 and 5. Tools to assist farmers with water use have been developed, the IPM guidelines are being revised, guidelines for selection of rotation crops have been published as have those for weeds and diseases, new system crops such as legume or retained stubble have been studied and research to define indices of soil health are underway. A soil database assistant for researchers and land managers has been developed, incorporating soil data from the three northern valleys. Additional milestones have been added, including (1) guidelines for optimising nutritional management and (2) development of an inventory of cotton soils, both of which are well underway. One area, the analysis and publication of results from the various farming systems experiments needs a more focused effort in reporting outcomes, especially to industry. There are also some areas of deficiency and one that stands out is the lack of research into the effects of GMO's such as Bollgard® II in the system, especially in relation to non-target effects. This is an area that the CRC will try to develop a presence in during the remainder of its life.

Project Summaries

PROJECT NUMBER: **3.1.02 AC**

PROJECT TITLE: **Identification of nutritional stresses in cotton crops**

STAFF:

Dr Ian Rochester, CSIRO Plant Industry, Narrabri NSW
Greg Roberts, CSIRO Plant Industry, Narrabri NSW.

AIMS AND MILESTONES:

- Further assess winter forage legume crops grown between cotton crops.
- Continue to assess commercial legume crops grown in rotation with cotton.
- Determine N response of cotton to the legume crops grown previously at ACRI.
- Finalise calibration of chlorophyll meter for assessing plant N status.
- Quantify organic acid production by legume roots and relate to soil amelioration.
- Collect further cotton leaf samples from diverse

fertility samples for comparative nutritional analyses.
- Devise relationships between nutrient concentrations in leaf material analysed using NIR.

OVERVIEW & OUTCOMES:

A major focus of this project will be the assessment of the potential for using rapid assessment technology to determine nutrient concentrations in cotton tissues. Currently, Near-Infra-Red (NIR) analysis has been used to assess N content of cotton, and this technology could be extended to analyse cotton plant tissues for all essential plant nutrients. We will continue development of the SPAD chlorophyll meter which is proving a reliable field-based means of determining the N fertility status in pre-flowering cotton crops. A means of interpreting crop nutrient analyses from these analyses and commercial laboratories will be incorporated into the NutriLOGIC program.

The development of N-efficient cropping systems using legumes will progress through assessing the value of green-manuring vetch species (and other legumes) grown between back-to-back cotton crops. Preliminary experiments have shown this type of cropping system to be relatively N-efficient as N fertilizer application rates can be substantially reduced and the supply of other nutrients to cotton may be improved. However, a more accurate means of determining the N fertilizer requirement of these cropping systems must be devised.

The previous project identified that legume cropping was associated with measurable improvement in soil quality. We will identify and examine the processes that contribute to soil quality improvement and determine the longevity of these effects.

Dr Ian Rochester being interviewed by Simone Cobb, ABC Radio - Rural Report.

PROJECT NUMBER: **3.1.03 AC**

PROJECT TITLE: **Integration of agronomy, crop physiology and modelling research capabilities**

STAFF:

Dr Michael Bange, CSIRO Plant Industry, Narrabri NSW
Dr Stephen Milroy, CSIRO Plant Industry, Narrabri NSW
Susannah Greig, CSIRO Plant Industry, Narrabri NSW
Dirk Richards, CSIRO Plant Industry, Narrabri NSW
Rose Roche, CSIRO Plant Industry, Narrabri NSW
Jane Caton, CSIRO Plant Industry, Narrabri NSW
Graeme Rapp, CSIRO Plant Industry, Narrabri NSW.

AIMS & MILESTONES:

To improve the interaction of agronomic, crop physiology and modelling research activities. The project provides technical resources, which contribute to the following specific project objectives:

- To assist with research to quantify differences between cotton varieties.
- The collection and processing of data to demonstrate the value of linking crop and soil monitoring with the predictive capability of simulation models.
- To assist with research to better understand environmental effects on fibre quality.
- To collect data to validate the OZCOT cotton model and sub-systems of the model including those related to sowing time, water extraction, short and long season cultivar development and fibre quality.
- To undertake research into the relationships between foliar nitrogen and photosynthesis.
- Assist in collection of data in waterlogging studies investigating the crop physiological responses, evaluation of transgenic varieties in the field, and impact of plant hormones.
- Collect data necessary for benchmarking whole farm water use efficiencies for comparing different crop management regimes.

OVERVIEW & OUTCOMES:

The aim of this project is to improve interaction of agronomic, crop physiology and modelling research activities through the provision of additional technical assistance for conducting research. In the past year the research team has conducted:

- Experiments to assess potential cold tolerance of cotton seedlings of Australian cotton varieties.
- Large scale field experiments that imposed drought stress on a range of diverse genotypes to establish understanding of the

PhD student Rose Roche measuring the difference in crop physiology parameters between ultra-narrow and conventionally grown cotton.

concept of crop determinacy.

- A number of field experiments across different regions that explored the impacts of temperature on crop growth and development.
- A series of glasshouse experiments to explore the impacts of cold nights on cotton growth and development.
- A field experiment to ascertain the potential to modify sowing time of Bollgard® II genotypes to reduce the effects of high fruit retention by increasing overall plant size.
- Research on the differences in crop physiology of conventionally grown cotton (1m row spacing) compared with ultra-narrow row systems. (Rose Roche PhD).
- An experiment exploring the interaction of Bollgard® II with its high fruit retention and limited water in reducing crop maturity.
- Two large scale field experiments to assess the functionality and value of HydroLOGIC, the soon to be released irrigation management software package. Treatments in which HydroLOGIC was assessed included variations in irrigation scheduling and variations in the availability of water for crop growth.
- Published papers based on our work in agronomy, crop physiology and modelling.

PROJECT NUMBER: **3.1.5AC**

PROJECT TITLE: **Sustainable Weed Management Systems for Cotton**

STAFF:
Dr Ian Taylor, NSW Agriculture, Narrabri, NSW
Benita Inchbold, NSW Agriculture, Narrabri, NSW
Leah Mackinnon, NSW Agriculture, Narrabri, NSW.

AIMS & MILESTONES:

a. Identify suitable low weed pressure fields and identify the major weeds, weed seed bank and other sources of infestation.

b. Establish and monitor best-bet treatments with reduced herbicide inputs on 3 candidate fields assessing weed pressure over time, seed banks and yield.

OVERVIEW & OUTCOMES:

The recent introduction of Roundup Ready cotton and new herbicide chemistry to Australian farming systems has increased the post–emergent herbicide options available to Australian cotton growers. Using this technology, a series of studies were initiated to determine if the elimination or reduction of residual herbicides from specific production systems is possible. These studies compared a number of herbicide treatments ranging from a full residual protection program, to Roundup Ready herbicide only. The experiments were conducted at two sites in 2001/2002 and three sites in 2002/2003. The sites were chosen specifically for the density of weeds with one site in the 2001 season having low weed density and the other with very high weed density. In the 2002/2003 season the three sites chosen had low, medium, and high weed densities respectively.

Results of the 2002/2003 season demonstrated that excellent weed control could be achieved in a commercial cotton field, using 85% less herbicide than is typically applied, resulting in a 60% reduction in weed control costs. This result was achieved using Roundup Ready cotton and reflects the benefits that new technologies offer both to growers and the environment. At the sites with high or medium weed density, the Roundup Ready only treatment gave good control early in the season, but late season weed control was poor. This poor control resulted in yield losses, and large returns of weed seed to the soil seed bank. Clearly a more intensive weed management is needed in these situations.

PROJECT NUMBER: **3.1.06 AC**

PROJECT TITLE: **Cotton Production Systems for Southern NSW.**

STAFF:
Dr Geoff Baker, CSIRO Entomology, Canberra, ACT
Dr Scott Hardwick, CSIRO Entomology, Griffith, NSW
Ms Kathy Semmler, CSIRO Entomology, Griffith, NSW
Ms Philippa Whiting, CSIRO Entomology, Griffith, NSW

AIMS & MILESTONES:

1. Develop optimum treatments for IPM trials for Ingard® and conventional cotton
2. Further develop and promote Area Wide Management strategies
3. Develop strategies that encourage the use of bioinsecticides
4. Promote appropriate resistance management strategy
5. Promote appropriate earliness strategy

6. Promote appropriate soil management practices for problem soils
7. Continue with collaborative project on seedling diseases

OVERVIEW & OUTCOMES:

Due to the drought and reduced water allocations the area of cotton planted was significantly less than in previous years in southern NSW. Research efforts were focused on gaining additional data to validate techniques proposed in the draft Area Wide Management (AWM) strategy for the control of *Helicoverpa* species in the mixed cotton and grains cropping region of southern NSW. The draft AWM strategy was completed during the 2002-03 growing season and has been circulated to producers and industry representatives. Key aspects of the AWM strategy are the use of trap cropping, nursery crops for beneficial insects, distruction of crop residues to remove overwintering *Helicoverpa* populations ("pupae busting"), and a regional Insecticide Resistance Management Strategy (IRMS).

Studies in early season crops have shown that early season *Helicoverpa* activity was initially concentrated in areas where chickpeas were grown. This has led to the recommendation that early season chickpea crops be used as a trap crop for *Helicoverpa spp*. Monitoring of specially planted late season pigeon pea trap crops showed that they were both attractive to *Helicoverpa* adults, and harboured large numbers of beneficial spp. species. Monitoring of lucerne crops also demonstrated their value as nurseries for beneficial insects as they harbour significant numbers of beneficials while producing very few viable diapausing *H. armigera*. Late season *Helicoverpa* activity is concentrated around cotton, soybean and late season sorghum and maize crops.

Surveys of the density of diapausing pupae in the region have shown that populations of *H. armigera* under late maturing cotton crops can be as high as those under soybean and late silking maize crops. If plantings of cotton increase at the expense of crops such as early-mid season maize, lucerne, sweet corn, sorghum and pasture there may be an increase in the size of the overwintering population of *H. armigera* within the region. This result stresses the need to cultivate cotton residues to reduce the survival of pupae that are potentially resistant to insecticides.

For the 2002/03 growing season the IRMS for grain crops in southern NSW and northern Victoria and for cotton crops were each revisited to ensure compatability of strategies accross the grains and cotton industries. This ensures that all growers within the region are broadly following the same IRMS strategy and prevents consecutive generations of *Helicoverpa* from being exposed to multiple applications of the same insecticide groups. Compatable IRMS is a feature for an areawide approach.

PROJECT NUMBER: **3.1.06 AC**

PROJECT TITLE: Cotton Industry Development Officer Griffith

STAFF:

Evan Brown, NSW Agriculture, Griffith, NSW.

AIMS AND MILESTONES:

1. Promote IPM strategies for Ingard® and conventional cotton
2. Develop strategies that encourage the use of bio-insecticides
3. Promote appropriate resistance management strategies (Joint, NSW Agriculture & CSIRO)
4. Promote appropriate earliness strategy
5. Promote appropriate soil management practices for problem soils
6. Continue with a collaborative project on seedling diseases

OVERVIEW & OUTCOMES:

The Cotton Industry Development Officer for the Lachlan and Murrumbidgee Valley plays a significant role in the development, promotion and technology transfer role in the most southern part of the cotton region. With the total area of cotton being reduced to 9250 hectares due to drought conditions, water use and its management was a key issue throughout the season. A review has been initiated to capture grower experiences from the season and will be compiled to improve overall water efficiency throughout the southern region.

The season began with the Water Management Workshop run in conjunction with Dirk Richards (CSIRO Plant Industry, Narrabri). This was a great success and the growers that came along were able to discuss and think about the issues of how they could use water efficiently and what would happen to cotton under water stress. Data will be collated from the southern region to improve the crop predictions generated from the Ozcot model.

Collaboration work with Scott Hardwick (CSIRO Entomology, Griffith) continued this year and there were 3 trials conducted to assess early plant damage (fruit removal and tipping out) and its impact on yield. This work was completed on conventional and Ultra Narrow Row cotton.

Other trials involved methods to improve crop earliness . A bio-degradable Mulch called Mater-B was shown to increase soil temperature and weed control. Ultra Narrow Row (UNR) cotton and a new system of "15 inch" cotton was examined. Development of a new picker for "15 inch" cotton may see significant expansion of this planting configuration in future years as the system appears to offer agronomic benefits.

The continued support of the Area Wide Management Groups in Hillston was a success with fortnightly discussions on insect pressure and pest control. These meetings provided the opportunity to conduct a number of field walks throughout the season. Topics included skip row cotton, management of Bollgard and Roundup Ready, crop defoliation, spray application and a soils Workshop. The annual Hillston field day was a success with over 40 people attending.

The ongoing development of cotton in the region meant that an "Introduction to Cotton Growing" seminar was held on the 1st May 2003 in Griffith with a similar seminar planned for Hay. There is potential for about 400ha in the 2003-04 season to be grown in the Griffith region and depending on water availability the Hay region may have as much as 5000 ha. Yields at Hay averaged 8 bales/ha and the use of "15 inch" cotton in this region will provide considerable benefits in crop earliness. Further research of this technology will form an important part of future trials in the region.

PROJECT NUMBER: **3.1.07AC**
PROJECT TITLE: **Sustainable farming systems: Optimising cotton farming systems using new technologies.**

STAFF:
Grant Roberts, CSIRO Plant Industry, Narrabri, NSW
Clare Felton-Taylor, CSIRO Plant Industry, Narrabri, NSW.

AIMS & MILESTONES:

1) Initiate innovative farming systems experiments to develop viable and sustainable cotton cropping systems. These will integrate outcomes from a range of disciplines including soil science, crop agronomy, insect, weed, disease and water management. Specific experiments include -:
- Crop maturity management and the association between maturity, yield and profitability.
- Dryland farming systems. Evaluate the value, fit and management of new transgenic herbicide tolerant cotton varieties in dryland cotton production. Emphasis has been placed on the Roundup Ready technology that is rapidly gaining acceptance across the industry.
- Evaluate the potential to agronomically adjust Bollgard II crops to maintain yield and quality.

2) Coordinate collaborative research and extension into cotton based farming systems.
3) Promotion of CRC farming systems research at field days, conferences and industry press.
- Coordinate and conduct measurements on the core CRC farming systems experiments at Warra.

OVERVIEW & OUTCOMES:
Farming systems research was conducted on a range of topics including late season crop maturity experimentation, agronomic aspects of Roundup Ready (RR) cotton management, herbicide control of seedling volunteer RR cotton and the interactions between agronomy and fibre quality.

Crop Maturity - Over the past few years a number of growers and consultants have experimented with the use of late season Pix applications as a tool to cause the crop to 'cut-out' early. This may ensure earlier harvest and in theory make the crop less attractive to insects, thereby reducing late season insecticide costs. Two experiments showed no effect of late season Pix applications (1.5 l/ha), with or without excess nitrogen, on yield or maturity. There was also no difference in *Helicoverpa* spp. numbers that could justify a change in insecticide applications. These results question the validity of late season Pix applications. However, pest pressure was light in 2002-03 and it is possible that a season with heavier pest pressure may provide different results.

Herbicide tolerant cotton - Lack of rainfall precluded Roundup Ready dryland experiments, however additional screening of herbicides and rates to control Roundup Ready volunteers was conducted. Robust rates of both paraquat+diquat and carfentrazone are still the most appropriate recommendations for controlling these volunteer plants prior to planting. Other experiments showed little impact of Roundup Ready herbicide on the abundance of early season beneficial insects. We also showed that a number of pre and post emergent herbicides had no significant impact on the amount of Bt in Roundup Ready Ingard varieties. In both cases this data dispelled concerns generated in the previous year. In addition we completed a final report for the OGTR titled 'Survey of cotton volunteers North of latitude 22 degrees South' This study demonstrated the low number of cotton volunteers found on northern roadsides, and suggests a relatively low risk due to transportation of fuzzy seed of transgenic cotton varieties for stock feed. The risk is further reduced by addition of covers to transport trucks that further reduces the chances of spillage.

Fibre Quality - Neps continue to be an issue for the fibre quality of Australian cotton. Over the last two seasons lint samples have been collected from a range of agronomic experiments. Data from these samples can be used to explore the relationship between agronomic management of cotton and the resulting fibre quality, including neps. These samples are now being tested on a neps machine at Auscott Sydney and sub samples sent to the CSIRO Textile and Fibre Technology to develop correlations between fibre parametics from HVI and FMT instruments and new CSIRO - developed maturity testing instrument. This should lead to more accurate estimations of fibre maturity.

Communications - This project continues to address key farming systems questions facing the cotton industry. Outcomes are being continually disseminated to industry at a range of venues including the World Cotton Research Conference, South Africa and at grower and consultant meetings.

Grant Roberts completing experimental work with farming systems.

PROJECT NUMBER: **3.1.08 AC**

PROJECT TITLE: **Ecology and development of management strategies for fusarium wilt in cotton.**

STAFF:

Dr Joe Kochman, QDPI, Toowoomba, QLD.
Linda Smith, QDPI, Indooroopilly Qld
Dr Suzy Bentley, CRC for Tropical Plant Protection, Indooroopilly, Qld
Linda Swan, QDPI, Toowoomba Qld
John Lehane, QDPI, Toowoomba Qld
Wayne O'Neill, QDPI, Indooroopilly Qld
Greg Salmond, QDPI, Dalby Qld
Lisa Gulino, CRCTPP/Aust. Cotton CRC, Toowoomba Qld
Emma George, QDPI, Indooroopilly Qld.

AIMS & MILESTONES:

AIMS

1 Monitor the diversity and distribution of strains of fusarium wilt in growing areas in Australia.
2 Develop a PCR-based detection system for fov.
3. Provide plant pathology support for investigations into the role of agricultural practices, such as stubble management, crop rotation, weed and water management on the ecology of Fov and on subsequent disease development.
4. Develop and extend new information packages for disease management.

MILESTONES

1. Complete planting of field trials by December and complete assessment by July 2002.
2. Complete disease surveys to determine the extent of the Fusarium wilt affected area by the end of May 2003.
3. Complete the monitoring of pathogen diversity, maintain the reference collection and wilt incidence database by July 2003.
4. Complete adaptation of the laboratory PCR detection system to soil and plant samples, by July 2003.
5. Develop information packages and extend to the industry, as results become available.

*Picture shows few plants surviving in a 4 row * 10 m plot of a susceptible variety (Pima type) amongst plots of more resistant varieties.*

OVERVIEW & OUTCOMES

Crop area was very significantly reduced in Queensland because of drought conditions and incidence of many diseases was reduced to trace levels. Fusarium wilt was not detected in samples from any new growing districts this season, but the number of properties confirmed as having the fungal pathogen continues to rise. A total of 144 diagnostic samples were received at Indooroopilly from NSW and Queensland for the 02/03 season. Of these, 69 returned a positive result for Fov and new recordings were made in the Macquarie, Upper Namoi, Gwydir and Macintyre Valleys in NSW and the Macintyre Valley and St George in Queensland. VCG 01111 was the only strain found in samples from new farms, although VCG 01112 continues to exist where it was originally identified.

About 25 hectares of field trials were planted at "Cowan" (Mr & Mrs G Clapham's property near Cecil Plains) in October 2002. There were more than 7000 plots in these trials which included assessment of germplasm and current variety reaction. Hot dry conditions caused some problems with initial emergence in these trials but subsequently there was significant disease pressure that allowed for differentiation of the germplasm being screened for resistance to Fusarium. Two trials of late planted plots (mid November) had very low disease incidence, confirming observations in previous seasons. The trials also include about 4 hectares of crop rotation experiments and a small number of trials with and

without Temik. Data from glasshouse bioassays suggest that soil from mungbean and soybean rotations cause significantly more cotton seedling deaths due to Fov than more resistant varieties of cotton, maize and sorghum, which are all very similar. There were significantly less cotton seedling deaths in soil from bare fallow treatments.

Validation trials of the PCR diagnostic test developed for Fov indicated that the test was able to differentiate accurately, between several Australian isolates of *F. oxysporum* and Fov and from international isolates of Fov, when the DNA was extracted from colonies grown in pure culture. Further validation trials were then devised using DNA extracted from some 2254 colonies growing on soil dilution plates from the rotation trials. During the processing of these samples, a small number of false positive and false negative reactions were detected in the *F. oxysporum* and Fov (VCG 01111) PCR tests but none for VCG 01112. There were about 8% false positives and 3% false negatives for *F. oxysporum* and 4.8% false positives and no false negatives with Fov (VCG 01111). This PCR test identified every isolate of both VCGs of Fov but the number of isolates of VCG 01111 was inflated by 4.8%. Further development and validation of the Fov DNA diagnostic test is currently underway to improve the accuracy of the diagnostic test on DNA extracted directly from seed, plant material or soil.

*Soybean, fallow, sorghum, maize, cotton and mungbean (plot size 120 m * 8 rows with 3 replicates) in trials to determine . The effects of some rotation crops on survival of Fusarium in the soil. Picture taken at Graham Clapaham's property 'Cowan' where we have conducted trials since 94/95 season.*

PROJECT NUMBER: **3.1.09AC**

PROJECT TITLE: **Pathogenicity and diversity of Thielaviopsis basicola**

STAFF:

John Harvey, PhD student, University of Queensland.
Dr Elizabeth Aitken, University of Queensland, St Lucia.
Dr David Nehl, NSW Agriculture, Narrabri, NSW.

AIMS & MILESTONES:

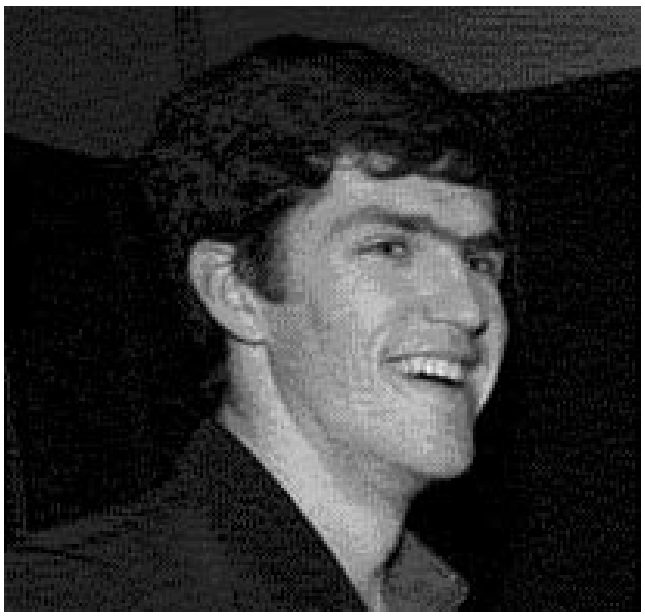
* Determine distribution of *T.basicola* outside of cotton fields.
* form pathogenicity trials, with particular emphasis on any strains isolated outside of cotton properties.
* complete molecular diversity analysis with RAPD's and evaluate other possible methods.
* Build culture collection.
* Examine relationship of diversity, pathogenicity and location.

OVERVIEW & OUTCOMES:

Black root rot (BRR) of cotton, caused by *Thielaviopsis basicola*, is an important seedling disease that can cause significant yield loss. The symptomatic stunting is particularly evident when seedlings are subjected to cold snaps in early season. Once the plant has matured *T.basicola* rarely causes disease symptoms but the stunting remains, resulting in reduced yield. The effects of BRR are of concern to most producers as early season disease surveys have shown the disease is widely distributed across NSW, yet little is known as to strain diversity or its origins. A greater understanding of this pathogen is required to aid in the implementation of control measures, particularly in terms of breeding strategies.

Investigation of the diversity of *T.basicola* is being undertaken using molecular marker techniques including randomly amplified polymorphic DNA (RAPDs). We have shown that strains of BRR originating from cotton fields are distinct from those associated with other crops. Further work is required, using other molecular techniques, to fully understand the differences amongst strains which infect cotton.

For a thorough understanding of BRR it is necessary to look beyond cotton fields. We are surveying areas that surround farms (including bushland) to determine if these are a source of inoculum. This is a possibility due to the wide host range of *T.basicola*. Results to-date indicate that surrounding areas are not a source, with the pathogen found in two locations both of which were associated with human disturbance.



PhD Student John Harvey

PROJECT NUMBER: **3.1.11AC**

PROJECT TITLE: **Dynamic modelling of soil physical-chemical processes as indicators of soil health in relation to land use in the cotton-growing regions**

STAFF:
Dr Inakwu O.A. Odeh, University of Sydney, NSW
Dr John Triantafilis, University of Sydney, NSW
Professor Alex. B. McBratney, University of Sydney, NSW.

AIMS & MILESTONES:
- Relate soil physical-chemical health indicators to different farming systems in the cotton-growing areas.
- Use simulation models to evaluate the temporal changes in soil physical-chemical health indicators due to or under different farming systems.
- Develop an integrated information system for the analysis of, easy assess to and retrieval of the soil physical-chemical data by the stakeholder's.
- Develop sampling protocols for the continual monitoring of soil health in relation to land use and agricultural productivity.

OVERVIEW & OUTCOMES:
Long-term sustainability of the cotton soil resource requires a better understanding of how various soil and crop management strategies affect productivity and environmental endpoints. To this end we analysed a range of soil quality indicators under various cultivation systems. Our analysis shows that soil organic carbon and total nitrogen decline with cultivation, whereas other indicators, such as sodicity (ESP) and salinity, show apparent improvement under cultivation.

While the decline in C and N may be explained by the effect of cultivation, possible explanation of decline in sodicity and salinity under cultivation may be due to the initial selection of optimal land for agricultural production, which apparently were naturally less saline and sodic than the unselected soils. As an example, most of the irrigated fields are located where sodicity is relatively low (Exchangeable Sodium Percentage or ESP is less than 3). However, the low ESP may also be attributable to flux of soluble ions under irrigation.
Further analysis using advanced statistical methods confirm some of the results above. However, the complexity in soil quality interaction with landuse show that detailed understanding of soil quality dynamics can only be reached through a farm and field level evaluation of nutrient balances, and the interactions of physico-chemical processes under a give production system. Comparisons across different agro-climatic zones show that while some soil quality measures show decline in some regions, the decline is not common. In fact soil quality is improving in certain areas due to improved management

In determining the sustainability of irrigation, there is no single index that would effectively encompasses all of the soil quality indicators and the nature of their decline (or improvement). Soil organic carbon can be regarded as the best measure of sustainability of cotton production in so far as soil quality is concerned. Subsoil salinity could also be used. Evidence from the results here indicates that salinity increases slightly at depth (± 200 cm) under irrigation when compared with uncultivated or non-irrigated soils, whereas there is little or no change at all in the topsoil.

Design of sampling protocols for monitoring soil quality in the cotton-growing areas is on track. This involves the combined use of soil and landscape variability relative to landuse patterns in the areas. Combining the various soil property maps with the map of the landscape would provide the optimal number of samples and their locations for more effective monitoring of soil quality. Digital soil maps and the various GIS layers are being integrated for publication on the Web as well as in other media for easy dissemination to the end users and stakeholders. In addition, an integrated soil database has been created, with a database assistant for simple querying and retrieval of data for various purposes and uses.

PROJECT NUMBER: **3.1.18 AC**

PROJECT TITLE: **The role of weeds as alternative hosts of Fusarium wilt in cotton**

STAFF:
Richard Kent, PhD Student, UNE, Armidale, NSW
Associate Professor Brian Sindel, UNE, Armidale, NSW
Dr David Backhouse, UNE, Armidale, NSW
Dr Joe Kochman, QDPI, Toowoomba Qld

AIMS & MILESTONES:
This study on the role of weeds and weed management in Fusarium wilt severity and management in cotton will ascertain which weeds act as alternative hosts to Fov, address the role that weeds play in inoculum build up and survival of Fov in the soil and develop an inoculum dynamics model to assist in managing the disease.

- Seed of all the major cotton weeds to be collected and screened to establish whether they are hosts to Fov.
- Relative inoculum build up due to species quantified.

OVERVIEW & OUTCOME:
It has been shown that some weeds are able to act as symptomless hosts to Fov. However, no comprehensive study into the role that weeds play in the epidemiology of Fusarium wilt of cotton has been carried out. The objective of this project is to fill this gap and provide recommendations regarding the management of weeds that minimises their impact on Fov inoculum and survival.

Following the appointment of Richard Kent in January 2002, collection of weed seed commenced. To date seeds from 70 different weed species, representing 23 families, have been collected. Collection of seed from other weed species is on going. Glasshouse experiments, to determine the ability of different species to act as alternative hosts to Fov are underway.

An extensive literature search on Fusarium wilt in cotton, with particular reference to the effect of weeds and other plant debris on Fov inoculum, has been completed. Much of the historic and current Fov research has been carried out in the USA where severe Fusarium wilt is usually associated with the root knot nematode. While this research may provide a guide for further research it is not directly relevant to the Australian situation.

Samples from a number of Fov injected fields produced 36 root samples, representing 22 weed species from 14 families. From these samples Fov was isolated from two species, *Impomea plebeia* and *Citrullus lanatus*.

Fov was not isolated from the remaining 30 of 32 weed species tested to date.

The capacity of staff at the University of New England to isolate Fov from a range of different source materials, to identify Fov isolates to the VCG level and confirm their pathogenicity to cotton has been developed.

PROJECT NUMBER: **3.1.19 AC**

PROJECT TITLE: **Agronomic factors affecting the efficacy of Bt in transgenic cotton.**

STAFF:
Dr Ian Rochester, CSIRO Plant Industry, Narrabri, NSW
Jenny Roberts, CSIRO Plant Industry, Narrabri, NSW

AIMS & MILESTONES:
Year 2: Determine levels of Bt in plant material collected throughout the season. Assess Bt efficacy in low fertility soils (N, P, K, Zn), cotton subjected to artificial low light conditions and temperature regimes.

OVERVIEW & OUTCOMES:
The cotton industry sees Ingard cotton as the basis for reducing the economic burden of *Helicoverpa spp* control and the environmental consequences of insecticidal sprays. Identification of means of realising the potential of Ingard cotton would assist the industry in economic terms and possibly help avoid problems of resistance to Bt genes.

Technology is now available to assess the efficacy of Bt with the aid of commercial quantitative Bt ELISA assays. This approach will now enable us to assess various agronomic and management factors which may have some impact on the efficacy of Bt. Numerous factors such as crop nutrition, temperature, solar radiation, herbicides, cotton growth regulators, water management, soil quality including salinity and/or sodicity.

We have observed few significant or substaintial responses in leaf Bt concentration using commercial qualitative Bt ELISA assays in this project that have been related to agronomic influences such as waterlogging, crop nutrition, temperature and light conditions, herbicides or growth regulators. Where substantial effects are found, the cotton plants are severely stressed and are such low productivity as to alter growers to a major problem. Low concentrations of Bt have been assayed in leafs showing seevere N, P and Zn deficiency symptions.

Recommendations for the growing of Ingard/Bollgard II cotton have not altered. Growers need to plant transgenic cotton in the most fertile fields and avoid waterlogging/ drainage problems and extremes of temperature and moisture stress.

This research will aid growers in their selection of fields for Bt planting and assist with management of those fields to maximise the efficacy of Ingard cotton.

PROJECT NUMBER: **3.1.20**

PROJECT TITLE: **Characterising soil structural stability and form of sodic soil used for cotton production**

STAFF:

Simon Speirs, PhD Student, The University of Sydney.
Dr Stephen Cattle, The University of Sydney, Sydney NSW
Dr Nilantha Hulugalle, NSW Agriculture, Narrabri, NSW.

PhD Student Simon Speirs

Above - Simon Speirs operating The University of Sydney's drilling rig - soil coring - with Dr Damien Field at a property north west of Moree.

AIMS & MILESTONES:

This project looks to address the sustainability of soil physical condition given the use of irrigation water of reduced quality, and where high quality water is available, the structural effects that may occur in sodic soil layers. An important outcome of this research will be a better understanding of how different cotton-growing Vertosols will respond to irrigation waters of decreasing quality. Consequently, three milestones were set for the end of the 2002-03 financial year:

- The completion of soil sampling from four cotton growing regions of N.S.W.; the Darling River (Bourke), the Lachlan (Hillston), the Lower Gwydir (Moree), and the Lower Namoi Valleys (Wee Waa).
- The determination of the structural stability of soil sampled from the irrigation furrow of cotton-growing fields from the Bourke and Hillston regions.
- To have underway the characterisation of the structural form of large soil cores from the Bourke and Hillston regions, treated with solutions of differing sodium contents.

OVERVIEW & OUTCOME:

At the completion of the 2002-03 financial year, sampling from the Darling River (Bourke), the Lachlan (Hillston), the Lower Gwydir (Moree), and the Lower Namoi Valleys (Wee Waa) is complete, providing us with bulk soil from both the irrigation furrow and sampled at 0.2 m increments to a depth of 1.2 m, and a number of large "undisturbed" soil cores.

During the year we worked to describe the structural stability of soil from the irrigation furrow of cotton growing profiles in the Bourke and Hillston regions when subjected to disruptive forces of low, medium and high energy. This was done using water of varing salinity (0, 0.2, 0.5 and 2.7 dS m-1) and sodicity (SARs of 0, 1, 7.5 and 15), and while currently incomplete, is beginning to highlight the differences in the structural stability of these soils.

The process of characterising the structural form of large soil cores collected from each of these regions is also well under way. Duplicate soil cores have been irrigated using either field water, de-ironised water or solutions of EC 0.5 dS m-1 across a range of SAR levels (0, 7.5 and 15) and subjected to a number of wet-dry cycles. Upon completion, cores have been set aside to further develop structural form in preparation for impregnation using a florescent resin and subsequently image acquisition and analysis. Further, in order to establish the structural stability of soils subjected to these wet-dry cycles, duplicate cores have also been prepared. These soils are to be assessed post-cycles, duplicate cores have also been prepared. These soils are to be assessed post-irrigation by applying disruptive force to soil aggregates immersed in de-ionized water.

During the 2003-04 financial year we look to complete

characterisation of structural stability and form attributes of soils collected from each of the four cotton-growing valleys mentioned. Using this information we will initiate a model of sstructure stability for cotton growing soils of N.S.W. Such a model will assist those growers who are considering the use of different water resources (i.e. bore water, river water) to manage the influence of salt across their property.

PROJECT NUMBER: **3.1.21 AC**

PROJECT TITLE: **Best weed management strategies for dryland cropping systems with cotton**

STAFF:

Dr Steve Walker, QDPI, Toowoomba, QLD.
Dr Hanwen Wu, QDPI, Toowoomba, QLD
Dr Ian Taylor, NSW Agriculture, Narrabri NSW
Vikki Osten, QDPI, Emerald, QLD
Geoff Robinson, QDPI, Toowoomba, QLD.

AIMS & MILESTONES:

- To improve management of key weeds (bladder ketmia, barnyard grass, liverseed grass, sowthistle, and fleabane) in dryland cropping systems with cotton.
- To monitor impact of weed management strategies applied in Year 1 on following crops and fallows in rotation;
- To implement additional field experiments on weed management of key summer weeds in the 'weak links' of cropping systems with dryland cotton;
- To measure changes in weed seed-bank.

OVERVIEW & OUTCOMES:

In 2001/02, a scoping study, funded jointly by CRDC, Cotton CRC and Weeds CRC, evaluated the weed issues of cropping systems with dryland cotton. The scoping study report highlights the common and difficult-to-control weeds in each crop and fallow component of the rotations used for dryland cotton production, lists all weed management practices currently used in these rotations, and identifies those practices possibly exacerbating the identified weed problems. The full report is available on the Cotton CRC website.

Five weeds, bladder ketmia, sowthistle, liverseed, barnyard grass, and fleabane, were targeted for improved management. Research will develop and validate technology to improve short-term weed control in the weak links of the crop rotations, and to reduce replenishment of the soil seed-bank for improved long-term weed control. Emphasis will be on better and consistent herbicide effectiveness, as well as chemical and non-chemical options to suppress weed seed production. A crop competition trial with sorghum sown in different row spacings is underway, and trials on controlling sowthistle and fleabane in winter fallow and wheat will commence shortly.

The outcome of this research will be best weed management (BWM) strategies for these key weeds. Modelling will be used to simulate the long-term impacts of these strategies for the different crop rotations. Weed biology studies have commenced to determine parameters for the model, such as emergence patterns and seed persistence in the soil seed-bank. Adoption of these BWM practices will create paddocks with low weed pressure and reduce the reliance on herbicides in the long-term.

Dr Hanwen Wu counting weed emergence in large in-ground pots at the DPI research station near Toowoomba.

Dr Steve Walker collecting liverseed grass seed at ACRI for Dr Hanwen Wu's seed persistence study.

A Field Day at the site of Hanwen Wu's field experiment on fleabane control in a sorghum fallow on a farm near Kindon QLD.

PROJECT NUMBER: **3.1.22 AC**

PROJECT TITLE: **Weed Resistance Risk Management Modelling for Glyphosate Tolerant Cotton**

STAFF:
Jeff Werth, PhD Student, University of Adelaide, Narrabri.
Dr Chris Preston, University of Adelaide, Adelaide, SA.
Grant Roberts, CSIRO Plant Industry, Narrabri NSW
Dr Ian Taylor, NSW Agriculture, Narrabri NSW.

AIMS & MILESTONES:

1. To investigate weed populations, weed management strategies and herbicide use patterns in Roundup Ready® and conventional cotton crops.
2. To investigate the population dynamics of weeds in cotton systems, focusing on two key grass weeds, Urochloa panicoides and Echinochloa crus-galli. However, other weeds may also be suitable to study as model plants.
3. To determine the possible interactions between population dynamics of these weeds and a number of weed management strategies:
   - Best IWM strategies with no Roundup Ready® Technology
   - Grass herbicides with no Roundup Ready® Technology
   - Best IWM with RRT
   - Half IWM with RRT
   - Roundup Ready Technology only
4. Develop a model from these experiments that will predict the likelihood of resistance evolution to glyphosate across a range of species and over a range of management strategies that will allow development of sustainable weed management practices utilizing Roundup Ready® Cotton.

OVERVIEW & OUTCOMES:
Glyphosate tolerant (Roundup Ready®) cotton was introduced in 2000 and now makes up approximately 40% of cotton plantings. This is likely to increase, especially with new Roundup Ready® technology on the horizon. While there is currently no glyphosate resistance in cotton systems in Australia, there is a concern about potential resistance and weed species shifts.

The prevention of resistance to glyphosate is vital for the cost-effective management of weeds in cotton farming systems, as there are no other herbicides that display the efficacy traits and which are as cost effective to use as glyphosate. This technology may also impact on Integrated Weed Management strategies that have prevented the evolution of resistance in weeds of cotton thus far. It is therefore important that the effects of management practices, particularly in glyphosate tolerant cotton, be examined for the influence on weed population dynamics and resistance selection. This will provide the ability to predict the likelihood and time frame for resistance evolution under different weed management options, and enable the possible altering of these to reduce the risks of resistance. PhD Student, Jeff Werth has recently commenced work on this project.

PhD Student Jeff Werth.

PROJECT NUMBER: **3.1.25 AC**

PROJECT TITLE: **Current and potential soil limitations to cotton production in the lower Lachlan River Valley region.**

STAFF:
Alex Onus, University of Sydney, Sydney, NSW
Dr Stephen Cattle, University of Sydney, Sydney, NSW

AIMS & MILESTONES:
•To characterise the soil types of the lower Lachlan River Valley used for cotton production.
•To ascertain which, if any, soil properties of the main cotton-growing soil types of the lower Lachlan Valley are currently limiting production.
•To determine which, if any, soil properties of the main cotton-growing soil types of the lower Lachlan Valley will potentially limit production.
•Integrate sample site information with additional ancillary information into a lower Lachlan Valley geological information system (GIS).

OVERVIEW & OUTCOMES:
This soil survey project was carried out in the lower Lachlan Valley around the township of Hillston with the aim of identifying current and potential soil limitations to cotton production in this region. The study area encompassed the majority of cotton-growing properties within the region, and involved the sampling of one hundred and fourteen soil

cores to a depth of 1.5 m. Sampling focused on the alluvial plains where cotton production is based, but also included areas of aeolian (wind blown) origin which exist in locations adjacent to the Lachlan River and its associated streams. Within the lower Lachlan cotton-growing area, three main soil classes were identified, each with distinct features which influence cotton production. These three soil groups were classified under the Australian Soil Classification system as Grey, Brown and Red Vertosols. It has been revealed that the greatest potential limitation to cotton production in the lower Lachlan is the threat of soil sodicity and structural instability, most prominently in the subsoils of this region. Other limitations which require further consideration in the lower Lachlan Valley are the issues of increased soil alkalinity, low organic carbon levels and subsoil phosphorus deficiencies.

A range of information layers including Landsat 7-TM, radiometric, geological and topographical data, have been sourced, purchased and incorporated with sample site information into a GIS for the lower Lachlan Valley region. Interrogation of this GIS aided the characterising of soil types within the lower Lachlan Valley, and ascertaining current and potential limitations to cotton-production in this region. This database is also being incorporated into the wider GIS currently being constructed in CRC projects 3.1.11 AC. This GIS database will act as a platform for further soil survey and detailed quantitative information for the lower Lachlan region, and hopefully aid management and decision making in cotton production in the future.

PROJECT NUMBER: **3.1.26 AC**

PROJECT TITLE: **Maintaining a functional soil system for improved cotton production.**

STAFF:

Professor Alex McBratney, University of Sydney, NSW
Dr. Damien Field, University of Sydney, NSW
Dr Peter McGee, University of Sydney, NSW
Dr David Nehl, NSW Agriculture, Narrabri, NSW.

AIMS & MILESTONES:

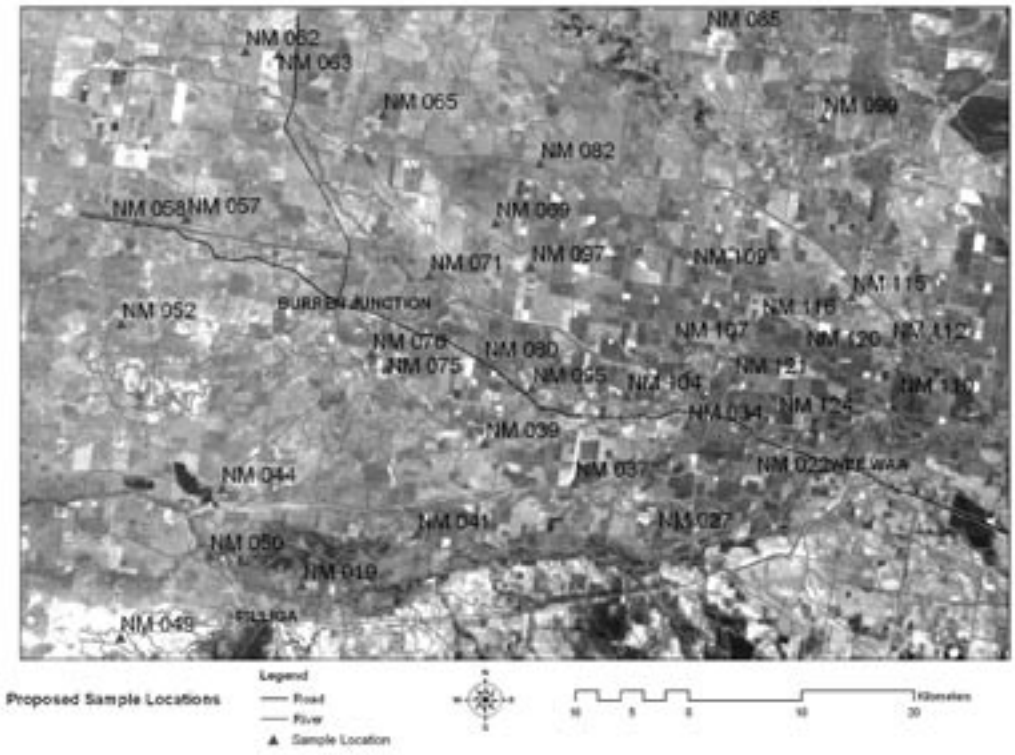
- To determine trigger amounts/ratios for various indicators, which signify that soil is in a good functional condition.
- To determine the dynamics of the interrelationships between various indicators identified that will signify soil is in a good functional condition
- To determine inputs required affecting the various indicators to maintain or improve the soil functional condition. Using the known distribution of soil properties of northern NSW (database from baseline studies conducted by Dr Odeh), in conjunction with Latin Hypercube procedure to develop initial sampling strategy.
- Commence sampling identified profiles.

OVERVIEW & OUTCOMES:

The utilisation of land for cotton production is often accompanied by the modification of existing, or development of new, crop management practices to accommodate the potentially limiting soil factors that may restrict cotton growth. Previous research of cotton growing soil has highlighted that some of the soil factors likely to restrict cotton growth may be broadly categorised into organic carbon decline, soil structural limitations, pH limitations and potential for salinisation. More recently at the CRDC soil health workshop, concerns have been raised regarding the lack of information of how changes in the soil microbial diversity may influence cotton production. Routine analysis of soil supplies information that is useful in managing the basic soil properties that influence cotton growth yet, the interrelationship and dynamics of the basic soil properties also needs consideration. The aim of this project is to understand the interrelationships between the driving soil physical, chemical and biological properties that can be used to develop a set of indicators enabling the ongoing maintenance of soil function for sustained and improved cotton production. These indicators will ultimately be incorporated into a model allowing for the prediction of changes in the soil function, i.e. soil function model. Using these predictions it should be possible to monitor the affect of and develop new management strategies to maintain good soil function for cotton production.

To understand the interrelationships and dynamics of soil properties influencing cotton production that will be incorporated into the soil function model a database of soil profiles that account for the potential variation found in cotton growing soil needs to be identified. Thus the initial efforts since the project commenced in January 2003 has been to identify a soil sampling protocol that accounts for the soil variation. This has been achieved by using a procedure known as Latin Hypercube sampling, which basically uses known distributions of soil properties in a given area to strategically select a representative subset of samples for collection. Sampling of these profiles and analysis of key soil physical, chemical and biological components has commenced.

Dr Damien Field selecting sampling identified soil profiles.



At this point some 20 soil profiles have been identified within the Namoi Valley selected from the 125 profiles supplied by the soil baseline data set being developed by the cotton industry for that valley.

PROJECT NUMBER: **3.1.29 AC**

PROJECT TITLE: **Maintaining profitability and soil quality in cotton farming systems**

STAFF:

Dr N. Hulugalle, NSW Agriculture, Narrabri, NSW
T. Weaver, PhD student, NSW Agriculture, Narrabri, NSW
L. Finlay, NSW Agriculture, Narrabri, NSW
Z. Hoque, NSW Agriculture, Narrabri, NSW
F. Scott, NSW Agriculture, Tamworth, NSW
J. Gleeson, Hons. Student, University of Sydney, NSW
A. Hicks, Hons. Student, University of Sydney, NSW
P. Roberts, Hons. Student, University of Sydney, NSW
Dr O. Jorar, NSW Agriculture, Narrabri, NSW
Dr P. Grace, CRC Greenhouse Accounting, ACT.
Dr I. Rochester, CSIRO Plant Industry, Narrabri, NSW
Dr S. Tennakoon CSIRO Plant Industry, Narrabri, NSW
Dr S. Mansfield, CSIRO Entomology, Narrabri, NSW
C. Tann, CSIRO Entomology, Narrabri, NSW.

AIMS & MILESTONES:

Determine the long-term effects of rotation crops and stubble management on carbon sequestration, soil quality and nutrient leaching; and growth, yield and profitability of succeeding cotton.

- Establish new cropping systems experiment at ACRI (Field D1), and conduct pre and post season soil sampling and EM38 surveys in lower and upper Namoi sites to evaluate soil quality and drainage with chloride mass balance method.
- Sow cotton and summer rotation crops in October-November at ACRI sites (Fields D1 and C1), and Warra. Soil water samplers to be installed in cotton treatments in ACRI, Wee Waa and Merah North for nutrient leaching monitoring.
- Sampling for soil quality at ACRI (3 experiments; Fields C1, D1 and F4), Warren, Warra, Boggabri and Merah North. Measure root growth in field C1.
- Data for economic analyses collected, & analyses commence after cotton harvest. Purchase @Risk for analysis of data.
- Sow winter rotation treatments.
- Commence soil analyses. Analyse root data.

OVERVIEW & OUTCOMES:

This project deals with soil and environmental factors which affect the sustainability of cotton production systems in eastern Australia. Key management issues considered in the project are tillage systems, rotation crops and stubble management systems, in particular, sowing cotton into standing wheat stubble, and their effects on soil carbon stocks, sodicity, salinity, deep drainage, profitability and root growth. In addition, researchers from other projects measure black root rot severity, insect dynamics, heliothis

pupae emergence, water use efficiency and greenhouse gas emissions in selected trials. The project consists of trials located on-station at ACRI, near Narrabri (3 trials), and on-farm near Narrabri, Merah North, Warra, Warren, Wee Waa and Boggabri (6 trials).

Soil structure deterioration occured at Merah North due to an increase in sodicity. Large increases in soil organic carbon took place at this site because of the wheat-sorghum sequence sown since the last cotton crop was picked in April 2001. Sodicity and salinity increased in the conventional cotton-wheat at Boggabri due to deterioration in irrigation water quality. Because of greater water infiltration in the standing stubble cotton-wheat, excess salts have been leached out of the cotton root zone and reduced salinity and sodicity. Carbon storage was improved by standing wheat stubble at both Boggabri and ACRI but not Warren. Measurements were also made in an experiment set up to identify effective pupae-busting practices which minimise soil structural degradation. Soil porosity was highest with centre-busting or no-till wheat. Preliminary analyses of pupae emergence suggest that there was no relationship between porosity due to tillage and heliothis moth emergence. Waterlogging was minimised in cotton sown into standing wheat stubble by retaining furrow stubble only until the start of the irrigation season to maximise rainfall harvesting. At this point a shallow sweep (10-cm depth) was run through the furrow and stubble cleared to facilitate water flow. However, a 2-m wide stubble buffer was retained at the tail-drain end to slow down water flow sufficiently to sediment out any clay and silt carried in runoff. Black root rot incidence was higher with intensive tillage than with minimum tillage. Compared with control treatments, cotton sown into standing wheat stubble produced between 19% and 51% more lint yield.

Root growth was measured with a minirhizotron during the 2002 winter on wheat and vetch crops, and on cotton during the 2002-03 summer. Numbers of earthworms were present under wheat and vetch. Large numbers of root hairs (the major sites of water and nutrient uptake) were also observed. However, cotton produces far fewer numbers of root hairs. Roots sampled during 2001-02 indicated that root mass for cotton by early December was 4-6 times greater than top growth.

Re-analysis of data collected between 2000 and 2002 showed that while frequently irrigated crops such as cotton and sorghum approached or reached steady state conditions, partially-irrigated or dryland crops such as wheat deviated markedly from steady state conditions and were best described by transient state conditions. Analysis of chloride profiles measured during 2001-02 at Federation Farm, near Narrabri, indicate that while deep drainage was moderate to low in Fields 1 and 2 (6-10% of total water inputs), it was relatively high (~40% of total water inputs) in Field 3. This was due to a high sand content layer in the subsoil, probably caused by the existence of a prior stream in this field. Using data collected in 2000-01 for model calibration, simulations of historical (1994-1998) deep drainage at “Glenarvon”, Wee Waa were made using WaterMod 2.1 with inputs of historical climatic and management records.

The ACRI Soils Team from left to right PhD Student Tim Weaver, Dr Nilantha Hulugalle and Lloyd Finlay.

Bigeyed Bug

Red and Blue Beetle.

Lowana Lady Bird.

PROJECT NUMBER: **3.1.30 AC**

PROJECT TITLE: **Enhancing the impact of early season predation on Helicoverpa spp.**

STAFF:

Dr Sarah Mansfield, CSIRO Entomology, Narrabri, NSW
Dr Lewis Wilson, CSIRO Plant Industry, Narrabri, NSW.
Dr Geoff Baker, CSIRO Entomology, Canberra, ACT
Judy Nobilo, CSIRO Entomology, Narrabri, NSW.

AIMS & MILESTONES:

This project investigates how key insect predators contribute to suppression of *Helicoverpa* spp. in cotton. The three aims are:

(1) to investigate the behaviour and ecology of key predators in relation to the suppression of *Helicoverpa* spp.,
(2) to explore the interaction between predator abundance, agronomic practices and predation of *Helicoverpa* eggs and larvae, and
(3) to determine whether a greater diversity of insect predators results in greater predation.

OVERVIEW & OUTCOMES:

Three strategies are being used to determine the importance of different insect predators in cotton: manipulative experiments, direct monitoring of insect abundance in commercial cotton crops and development of a molecular technique (ELISA) to detect consumption of *H. armigera*.

Bigeyed bugs feed readily on *H. armigera* eggs and neonate larvae, although adult bugs consume more neonates than eggs under laboratory conditions. Protocols for ELISA analysis are in development for bigeyed and damsel bugs. Some red and blue beetles collected in 2001-02 have already tested positive for *H. armigera* proteins and more than 3000 specimens from the 2002-03 season have been stored for future analysis.

Beneficial insects and spiders were monitored in three fields at ACRI, four fields in the Namoi and Gwydir valleys and six fields in the Macintyre valley. These fields represented a range of cropping systems and varieties (conventional, Ingard, unsprayed, dryland, irrigated, retained stubble). Beat sheet samples and visual checks were taken at each site once a month from November to February. All beneficial predators were counted and identified, usually to species. The most abundant beneficial predators in the sampled fields for the 2002-03 season were red and blue beetles, spiders and predatory bugs. Beneficial insect and spider abundance was lower in fields that experienced a “harder” spray regime compared with fields that received softer sprays.

PROJECT NUMBER: **3.1.12 AC**

PROJECT TITLE: **Cotton soil health: influence on cotton root diseases**

STAFF:
Florian Yan, PhD student, The University of Sydney.
Professor Les Copeland, The University of Sydney. NSW
Dr David Nehl, NSW Agriculture, Narrabri, NSW
Dr Tony Vancov, NSW Agriculture, Orange, NSW
Dr David Backhouse, The University of New England, Armidale, NSW.

PhD Student Florian Yan

AIMS & MILESTONES:
The milestones to be achieved within the past year of the project were:

- To assess the diversity of the soil bacterial community using a DNA-based analysis called length-heterogeneity polymerase chain reaction (LH-PCR), on samples taken from the field during the 2002/2003 cotton season
- To demonstrate black root rot suppression in cotton soils through greenhouse trials, and to determine the relative role of biological factors in the suppression of black root rot in certain soils
- To commence writing a PhD thesis

OVERVIEW & OUTCOMES:
Black root rot of cotton (*Thielaviopsis basicola*) is a widespread disease of cotton, which has been observed to be more severe in some soils than in others. The receptivity of a soil to disease may depend on only physicochemical factors, or may involve biological factors as well. Circumstantial evidence has led us to hypothesize that microbiological factors are involved in the suppression of black root rot. Greenhouse experiments have been initiated to determine whether or not our hypothesis is true. Soil microbial communities in soils with high and low receptivity to black root rot are being assessed to determine if there are characteristic differences between these communities. The method of assessment being used is a DNA-based technique (LH-PCR) which provides a 'snapshot' of the diversity of the microbial community, and more specific information on the major microbial groups present in the soil will be available if DNA sequencing becomes feasible for this project.

Black root rot in Siokra 1-4.

PROJECT NUMBER: **3.2.00 AC**

PROJECT TITLE: **Understanding the salinity threat in irrigated cotton growing areas of Australia - Phase IV – Interpretation and Extension**

STAFF:
Dr John Triantafilis, University of Sydney, NSW
Sam Buchanan, PhD Student, University of Sydney, NSW
Dr Inakwu Odeh, University of Sydney, Sydney, NSW.

AIMS & MILESTONES:

1) Extend existing piezometer network and collect additional soil and water data in the Bourke Irrigation District to enable the development of a groundwater flow model to understand saline groundwater interaction from irrigation and the Darling River,
2) Extend and interpret earlier results to achieve improved natural resource management through:
   a) development of a Geographic Information System (GIS);
   b) development of a Webpage to allow extension

officers and growers access and ability to query interpreted data layers stored on the GIS;

c) publications in international and Australian soil and water journals; and,

d) publications in industry journals and periodicals.

PROGRESS AGAINST AGREED MILESTONES:

Milestones as compared with stated aims:

1) The piezometer network has not been upgraded due to funding constraints within the Department of Planning, Infrastructure and Natural Resources. Funds will be requested as part of the NHT EnviroFund: applications due July 4.
2) Extend and interpret the results and data from Phase III and IV for improved natural resource management through:
   - GIS development is dependent upon receiving funding from other sources. Funds have been requested from the Environmental Trust.
   - GIS webpage development. As for part 2a.
   - Several research manuscripts have been submitted for publication in various soil and water science journals.
   - Various articles are being prepared for publication in the Australian Cotton Grower.

OVERVIEW & OUTCOMES:

The project aims to consolidate research undertaken as part of Phase's II and III, synthesising data into results that can be extended and used as a framework for improved natural resource information in various irrigated cotton districts of south-eastern Australia. This includes, Toobeah (Macintyre), Ashley (Gwydir), Wee Waa and Breeza Plains (Namoi), Warren and Trangie (Macquarie) and Bourke (Darling River valley).

In Bourke (Darling River) a hydrological study is being undertaken to determine why salinisation is a problem. This will be achieved using piezometer information and existing soil information (western side). The DLWC (Far-West Region) is keen to collaborate and provide funds to carry out this program. Mr Sam Buchanan (PhD student) will carry out the project in consultation with Mr Derek Yates (National Centre for Groundwater Management: UTS). The research carried out can be used as a template for determining a suitable procedure to understand and model the hydrological impacts of irrigated cotton in other areas.

PROJECT NUMBER: **3.2.01 AC**

PROJECT TITLE: **Development of an integrated system for remediation of waterborne pesticide residues on cotton farms.**

STAFF:

Mick Rose, PhD Student, The University of Sydney, NSW.
Dr Angus Crossan, The University of Sydney, NSW
Dr Ivan Kennedy, The University of Sydney, NSW

AIMS & MILESTONES:

- Continue laboratory plant and microbial biodegradation trials
- Refine/remodel design on first site following results of previous year
- Construct second pilot site; including adsorption (stage 4) if necessary
- Reassess environmental and economic performance

OVERVIEW & OUTCOMES:

This project is aimed at assessing the benefits of constructed wetlands on cotton farms, in particular, the removal of pesticide residues from irrigation tailwater. Two pilot-scale systems are being studied: a ponded wetland (constructed in 2001), which stores water between irrigation events and consists of an open and a vegetated pond in series; and a flow-through wetland, (constructed in 2002) which permits faster reuse of tailwater on the farm.

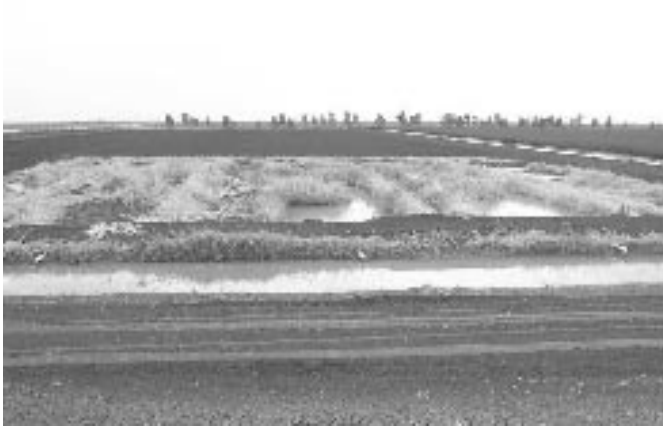
A baseline assessment of the ponded wetland was conducted over the 2001/2002 cotton season. Average reductions of 15% for fluometuron, 30% for aldicarb and 38% for diuron were observed in both vegetated and open ponds over a 10-14 day period, with no significant difference between ponds. A second-year assessment over the 2002/2003 cotton season demonstrated a significantly higher capacity for pesticide removal, with average reductions of 50% for fluometuron, >70% for aldicarb and 77% for endosulfan. This was most likely due to a greater area of plant coverage in the vegetated pond than the previous year.

The flow-through system was also assessed over the 2002/2003 cotton season. It was found that pesticide removal was greater in sub-surface channels (gravel beds) than surface-flow channels in early season irrigations, probably due to adsorption by bacteria growing on the gravel. However, subsequent irrigations were seen to release some of the pesticide adsorbed in earlier irrigations, indicating that pesticide breakdown between irrigations is limited in the sub-surface flow channels. Reassessment of this system over the next cotton season will investigate whether breakdown can be enhanced between irrigations by addition of pesticide-degrading bacteria or plant growth in the gravel beds.

The major highlight of this project has been the interest

demonstrated by the cotton industry in developing on-farm wetlands as a tool to benefit the agro-environmental landscape. Although the primary objective of this project was to investigate a pesticide-bioremediation system based on constructed wetlands, a number of other potential benefits have also been recognized. These include the use of on-farm wetlands to reduce sediment and nutrient loss in irrigation runoff, increase on-farm biodiversity, provide livestock feed and enhance pest management by fostering beneficial insect populations.

Another benefit provided by this project would be the on-going use of the trial sites as an educational tool for cotton growers, other agriculturalists, students and members of the wider community. A number of cotton growers have already visited at least one of the sites and expressed interest in developing similar systems on their own properties. A field trip with 20 undergraduate and postgraduate students from the University of Sydney also involved an in-depth tour of both sites and a discussion of their chemical and biological importance. It is anticipated that these sites will be frequently used in the future to promote a better understanding of opportunities for effective use of on-farm wetlands.



An on-farm wetland at 'Auscott' Narrabri

PhD Student Mick Rose completing experimental work with a vegetated pond.

PROJECT NUMBER: **3.2.02 AC**

PROJECT TITLE: **Economic value of ecosystem services underpinning the Gwydir Valley cotton industry.**

STAFF:
Assoc. Prof. Nick Reid, UNE, Armidale, NSW
Dr Letitia Silberbauer, UNE, Armidale, NSW
David Thompson, CARE, Armidale, NSW

AIMS & MILESTONES:
The aims of this research are to quantify the use of ecosystem services (biophysical flows and products) by the cotton industry in the Gwydir Valley, and to assess their economic value to the industry. Our milestones are:

1. To complete bio-economic models of target ecosystem services in the cotton industry at both farm and catchment scale.
2. Collaborate with NSW Department of Infrustructure, Planning and Natural Resources' IQQM developers to link the IQQM model with our bio-economic model to examine the ecological impacts of several water plans.
3. To customise international estimates of the value of ecosystems services to the Gwydir Valley and to the cotton industry in Australia and thereby gain an estimate of the value of ecosystem services to the cotton industry in the Gwydir Valley.
4. Prepare the community forum report for publication in book form.
5. Submit NHT2 applications through the Cotton CRC, catchment management boards and catchment management authorities.

OVERVIEW & OUTCOMES:
What are Ecosystem Services? Our working definition is that ecosystem services are the ecological conditions and processes that maintain soil, biota, aquatic systems and the atmosphere (i.e. our natural assets) and use those assets to produce goods that people want and need. Ecosystem services derive from ecological processes. Examples of ecosystem services in rural catchments include the provision of clean water, adequate amount of water, habitat, aesthetically pleasing landscapes and recreational outlets, as well as pollination, natural pest control, local climate control, bioremediation of toxic compounds, and mitigation of extreme climatic events.

In this project we have created biophysical and economic models of two ecosystem services important to cotton production in the Gwydir catchment – natural pest control (the action of beneficial insects in controlling insect pests) and water (a suite of ecosystem services related to water provision and quality). We have modelled natural pest control at the farm scale, modelling the economic and ecological impacts of adopting 'soft' versus 'conventional' pest management strategies over a 10-year period under varying levels of insect pest pressure. We modelled water at both the farm and catchment scale. At the farm scale we modelled the economic and ecological impacts of four different irrigation technologies - conventional furrow, precision furrow, sub-surface drip and overhead spray. At the catchment scale we linked our model to NSW Department of Infrastructure, Planning and Natural Resources' IQQM model and investigated the economic (to cotton growers) and ecological impact of several of the new water plans introduced by the State government.

Our results are being published as a book reporting the Gwydir community's views on ecosystem services, as scientific manuscripts for publication in international refereed journals and as extension material for cotton growers. The target of the extension material will be the benefits of ecosystem services, cotton growers' dependence on ecosystem services and cotton growers' role in safe-guarding ecosystem services for themselves and the wider community.

PROJECT NUMBER: **3.2.07 AC**

PROJECT TITLE: **The Effects of Cotton Defoliants on Native Trees from North-West NSW – Field-Based Experiments.**

STAFF:
Adam Downey, PhD Student, UNE, Armidale, NSW
Assoc/Prof. John Duggin, UNE, Armidale, NSW
Guy Roth, CRDC, Narrabri, NSW
Trevor Stace, UNE, Armidale, NSW
Assoc/Prof. Nick Reid, UNE, Armidale, NSW.

AIMS & MILESTONES:
To determine whether cotton defoliant chemicals affect native tree species common to the cotton growing areas of north-west NSW through spray drift impaction.

1. Complete further 4 to 5 tree measurements for Experiments 1 and 2;
2. Apply third and final treatment application of cotton defoliants for Experiments 1 and 2;
3. Carry out regular site maintenance;
4. Finalise first and second year results and begin integrate those with third year results;
5. Compile draft literature review by February 2003;
6. Maintain supporting glasshouse experiments and carry out treatments application during the first half of 2003;
7. Submit final thesis document on 24 January 2004

OVERVIEW & OUTCOMES:
Two field experiments were established on two cotton production properties near Boggabri, in north-western NSW in September 2000. Approximately 1300 juvenile trees were planted in plots at "Kilmarnock" and "Milchengowrie". Seven tree species were used in the trial including one

Acacia, Myall (*A. pendula*), two Casuarina's, Belah (*C. cristata*) and River She-Oak (*C. cunninghamiana*) and five Eucalypts, River Red Gum (*E. camaldulensis*), Yellow box (*E. melliodora*), Coolibah (*E. microtheca*) and Poplar/Bimble Box (*E. populnea*) which are all relatively abundant species in the region.

The experiments involved spraying the trees with four commonly used defoliants, Dropp Liquid ® (Thidiazuron), Dropp Ultra ® (Thidiazuron and Diuron), Prep 720 ® (Ethephon) and Atlacide ® (Sodium Chlorate) in seven treatments (including a Control – no treatment) applied at three rates; high, medium and low, based on the standard rates (ie. standard is the high experimental rate) for each chemical in commercial cotton production. Treatments were applied twice each year during April for three consecutive defoliation seasons between 2001 and 2003.

Treatments are applied directly onto the trees, which simulates a worse case drift scenatio. Variables measured to assess defoliant impact include; height growth, lateral shoot growth, leaf spot necrosis, leaf margin necrosis, actual leaf loss or defoliation, apex (i.e. apical growing shoot) death or damage and mortality.

Currently, the project is in its final experimental stage, as the third and final season of treatment application and spraying has recently been completed, while some final data collection is to be completed. After two seasons preliminary results have shown that three out of the four chemicals used; Atlacide ®, Dropp Ultra ® and Prep 720 ® have had negative impacts (ie. slowed growth, leaf necrosis, defoliation etc) to varying levels on four of the tree species, when compared to the control trees. The most affected species have been River Red Gum, both Casuarina's and Poplar Box. These results highlight a species affect, a treatment or chemical effect and to a lesser extent an application rate effect, as the higher rate appears to cause the most significant impacts. It is noteworthy that despite the trees being sprayed directly no trees have been killed by any defoliant.

Adam Downey using the modified boom spray to apply one of the experimental treatments.

PhD Student Adam Downey

Trees at approximately 2 3/4 years old at "Kilmarnock" Boggabri.

*Effect of the NaC13 * NaC13 (Salt - Sodium Chlorate) treatment at the high rate on Eucalyptus Camaldensis (River red Gum).*

PROJECT NUMBER: **3.2.08 AC**

PROJECT TITLE: **Hydrological modelling to develop sustainable irrigation management practices in cotton production**

STAFF:
Dr R. W. Vervoort, University of Sydney, Sydney, NSW
Dr. Stephen Cattle, University of Sydney, Sydney, NSW
Dr Damien Field, University of Sydney, Sydney, NSW
Dr Budiman Minasny, University of Sydney, Sydney, NSW

AIMS & MILESTONES:
To develop the concept of soil inference systems, which can be implemented as a toolkit for predicting hydraulic properties.

OVERVIEW & OUTCOMES:
With the projects completion in December 2002 one of the major outcomes has been the development of the concept of soil inference systems (SINFERS), which can be used to predict soil water properties that can be used by other toolkits to estimate the soil water balance. Basically SINFERS works on the principle of 'what we want from what we have', achieving this by taking measurements we know with a certain precision and inferring properties we don't know with a given precision. The SINFERS concept consists of three components, which are the source, the organiser and the predictor.

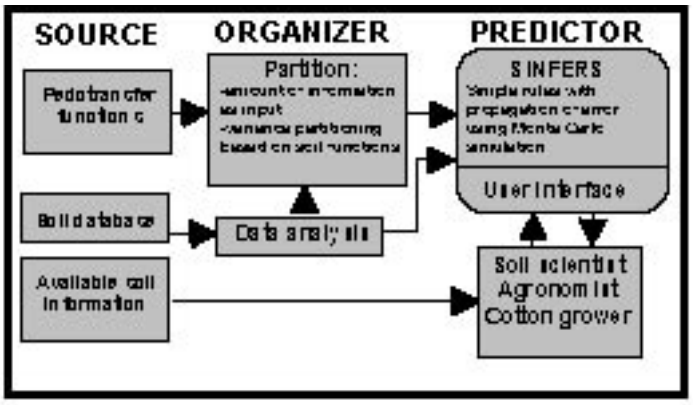


Figure 1. The SINFERS concept (McBratney et al., 2002)

The source of the 'knowledge' to predict the soil properties are a collection of pedotransfer functions (PTFs) and soil database. The organiser arranges the PTFs with respect to their required inputs and soil type. The predictor uses a collection of rules to select PTFs with minimal variance to return predictions of soil properties including their uncertainty. To make the SINFERS concept user friendly a graphical user interface has been developed. The GUI consists of a series of input and output windows enabling growers and extension staff to enter their data and obtain a summary of the predictions with their associated error. The output window also uses colour coding of the error outputs to warn users of predictions with high uncertainty and, if required more detailed output display can be requested .

The completed SINFERS toolkit and documentation will be delivered with the final report and this will allow other projects to use the toolkit to predict and simulate soil water interactions. The toolkit can also be easily expanded (if the data are available) to include all water balance sites used to validate the OZCOT model.

PROJECT NUMBER: **3.2.12 AC**

PROJECT TITLE: **The role of native vegetation in harbouring beneficial insects and reducing insect pest damage in cotton**

STAFF:
Ingrid Rencken, PhD student, UNE, Armidale, NSW
Dr Letitia Silberbauer, UNE, Armidale, NSW
Assoc. Prof Nick Reid, UNE, Armidale, NSW
Assoc. Prof Peter Gregg, UNE, Armidale, NSW.

AIMS & MILESTONES:
- Identify native vegetation at prospective experimental site.
- Collect and sort insect samples from the native vegetation (riverine, native grasses, pastures, planted native windbreak and dryland lucerne) from July 2002-February 2003.
- Pilot colonisation study of newly planted cotton fields to investigate mobility of predators.
- Analysis of native vegetation data (first season sampling).
- Analysis of pilot colonization study.
- Complete Macvac efficiency experiment.
- Present 1st year data World Cotton Conference/ CRC research committee.

OVERVIEW & OUTCOMES:
Conservation biological control has largely been ignored within many IPM programmes. The introduction of habitat management as a method of conservation biological control has changed this trend. Habitat management exploits the surrounding vegetation as a potential source of predators and parasitoids. This is achieved through modifying the surrounding habitat to enhance predator and parasitoid efficiency through reducing sprays and encouraging the surrounding vegetation to flourish. In Australia many generalist predators have been identified within cotton agricultural landscapes and these generalist predators can play a significant role in managing cotton pests.

The aim of this study is to investigate whether the native and

non-cotton crop vegetation, within the cotton agricultural landscapes, support populations of generalist predators. This will be achieved through sampling the native vegetation and winter crops adjoining cotton fields. Colonisation studies will investigate the movement of predators from the surrounding vegetation into cotton fields. The resources provided by the native vegetation and winter crops will be established and potential of habitat management within the cotton agricultural landscape, as a means of generating populations of predators, will be assessed.

Results from the first season of sampling indicate that there are populations of generalist predators in the surrounding native and non-cotton crop vegetation. Whilst the population numbers are low it does suggest that some of the surrounding vegetation may be important in generating predator populations. The colonisation studies indicate that predators do migrate into the cotton. These are however preliminary results and will be confirmed with another season of sampling.

PhD Student Ingrid Rencken collecting insect samples.

PROJECT NUMBER: **3.1.18 AC**

PROJECT TITLE:**Measuring the Influence of Varying Water Quality on Drainage Through Irrigated Cotton Soils.**

STAFF

Dr Naidu Bodapati, Dept. of Natural Resources and Mines.
Rachael Zischke, Dept. of Natural Resources and Mines.
Ian Gordon Dept. of Natural Resources and Mines, Indooroopilly, QLD

AIMS & MILESTONES

* Continuation of irrigation simulations on soil columns.
* Completion of simulation trials on three lysimeters.
* Installation of further 2 drainage meter sites.
* Sample collection from drainage meters.
* Collation and analysis of data.

OVERVIEW & OUTCOMES:

We have installed and instrumented mini-lysimeters at 3 sites in Queensland cotton fields (namely St George, Macalister near Dalby and Goondiwindi) and are functioning well. At all 3 sites deep-drainage was highest at the head ditch, medium at the middle-lysimeter and the lowest at the tail end. Distance from the head-ditch and/or the residence time of water on the soil seems to determine the amount of deep-drainage. Average cumulative deep-drainage varied between sites: It was 132, 61 and 21 mm, at Dalby, Goondiwindi and at St.George, respectively.
Initial results from soil moisture characterisation using disk permeameters using saline, and rainwater at Macalister have been veryinteresting. Saline water caused significantly more soil hydraulic conductivity (K). There was a general tendency for the soil hydraulic conductivity to be greater at 150 cm depth compared to 30 and 60 cm depths. Lower conductivity was observed at the depth of 60 compared to 150 cm depth (to some extent at 30 cm also) and this may be a reflection of hard soil pan.

Glasshouse experiments to measure deep-drainage of soils involving field collected soil columns and different qualities of irrigation water have commenced. The 4 qualities of water that we are currently using include, (a) deionised water or good quality irrigation water (EC<0.3; SAR<5), (b) high saline (3 dS/m) and low sodic (SAR<5), (c) high saline (3 dS/m) and high sodic (SAR>15), and (d) low saline (<0.3 dS/m) and high sodic (SAR>15). Deep-drainage response of the 3 cotton soils after irrigation with good quality water was similar to that described (above) from the field measurement. Irrigation with the other 3 qualities of water is currently in progress.

PROJECT NUMBER: **3.2.20 AC**

PROJECT TITLE: **Hydrological and geophysical characterisation of palaeochannels in Northern New South Wales**

STAFF:
Chris Vanags, PhD Student, University of Sydney, NSW
Dr. Willem Vervoort, University of Sydney, NSW
Diana Bennett, University of Sydney, NSW.

AIMS & MILESTONES:
The aims of this project are to:
* characterise and quantify the geomorphology of a palaeochannel (P-C) in New South Wales using geophysical, soil physical and pedological methods;
* quantify the interaction between shallow groundwater tables, river flow and irrigation;
* identify the impact of P-C's on shallow seasonal water tables and return flows to rivers, using 2- and 3-dimensional simulation modelling; and using this information
* identify irrigation strategies and management options for irrigated cotton fields in which P-C's occur.

OVERVIEW & OUTCOMES:
Currently, one of the largest problems facing the Australian irrigator is water availability. Due to depletion of resources, the need for environmental flows, salinisation, and growing populations, the demand for water has become one of the most pressing issues in natural resource management. At present, issues such as deep drainage and rising water tables are being addressed in the scientific and agricultural communities, but solutions to these problems are complex due to soil heterogeneity and lack of information on deep drainage pathways. Improving water use efficiency in irrigated cotton production hinges on a complete understanding of where irrigation water is going once it is applied to the surface. Our study aims at looking into how palaeochannels* in a field might influence deep drainage and ground water movement in the irrigated landscape. We intend to study furrow irrigation on a cotton paddock adjacent to a presently-flowing stream, with the paddock containing a small palaeochannel.

Progress against milestones:
Since there is still no funding available for hyfrological instrumentation in this project we have not proceeded in this area. We have however identified a site, which is close to Carroll Creek, North of Moree. At this site we have sampled soils and surveyed the area extensively with geophysical instruments. We are currently working on calibration of the geophysical instruments and analysis of the soil data. We are also working on studying the surface water and underground interaction on a smaller scale using a physical model of a groundwater system in the laboratory. The results are being interpreted using MODFLOW and will be used to

Dr Willem Vervoort, University of Sydney , inspecting a soil core taken from a palaeochannel at Auscott, Midkin.

Guillaurie Mary an exchange student from ENSAM and Chris Vanags perform a ground-penetrating radar survey at Auscott, Midkin.

PhD Student Chris Vanags taking notes at his study site at Auscott, Midkin south near Moree.

interpret data from the field site. We are negotiating with the Department on Infrustructure, Planning and Natural Resources about a larger study to investigate the groundwater system in the Narrabri formation at the same site.

*about palaeochannels:
Although the term “palaeochannel” may not be a frequently used, most irrigators can point out their presence in the landscape. Palaeochannels, otherwise known as “relict channels” or “prior streams”, are commonly found throughout the Australian landscape. These relict stream beds are the remnants of older climactic regimes, where rivers have since diverted or dried up. They tend to contain coarser sediments than the surrounding soils and are buried by younger aeolian and fluvial sediments, making them topographically unperceivable. However, their presence is usually marked by changes in vegetation or crop yield, depending on land management strategies.

PhD Student Chris Vanags.

PROJECT NUMBER: **3.2.22 AC**

PROJECT TITLE: **Sequestration of carbon below ground by arbuscular mycorrhizal fungi and cotton roots**.

STAFF:
Leonie Whiffen, PhD Student, University of Sydney, NSW
Dr Peter McGee, University of Sydney, NSW.
Dr David Nehl, NSW Agriculture, Narrabri, NSW.
Professor Les Copeland, University of Sydney, NSW.
Dr Nilantha Hulugalle, NSW Agriculture, Narrabri NSW.

AIMS & MILESTONES:
The project aims to clarify the turnover of carbon in soil used to grow cotton with the goal of identifying approaches that may increase the amount of carbon sequestered and its persistence in soil.

OVERVIEW & OUTCOMES:
Organic carbon in soil arises from both plant and microbial sources. The carbon associated with roots has been studied, and that associated with cotton appears to degrade rapidly. However, the carbon associated with microbes is less understood. In particular, the glycoprotein glomalin, formed by arbuscular mycorrhizal fungi, appears to be long-lived and persistent. Glomalin accumulates in soil to concentrations of several mg per cm3, and is highly correlated with aggregate stability. Glomalin may coat soil particles, and those areas inside aggregates are likely to be protected. Thus understanding the role of glomalin may lead to understanding processes that enable increased storage of carbon in soil.

The study of glomalin relies on understanding the dynamics of root and mycorrhizal fungus to determine where and when glomalin is formed and excreted, and its fate once in the soil. Measures to quantify the protein are also essential. Recent publications indicate that immunological techniques provide a relative measure that can be used to compare experimental treatments. Further, unplublished data indicates that the soluble form of glomalin can be extracted from axenic cultures. These techniques will allow experiments in which the contribution of glomalin to soil carbon can be separated from that of plants and fungi.

PhD Student Leonie Whiffen.

PROJECT NUMBER: **3.2.28 AC**

PROJECT TITLE: **Cotton gin trash and agroforestry for sustainable soil management**

STAFF:

Dr. N. Hulugalle, NSW Agriculture, Narrabri, NSW
Dr. G. Dale, SaltGrow Pty. Ltd., Qld.
L. Finlay, NSW Agriculture, Narrabri, NSW

AIMS & MILESTONES:

- Use composted cotton gin trash and pelletised cotton gin trash to monitor soil response and soil nutrition benefits
- Establish experimental woodlots of salt/waterlogging tolerant eucalypts with pelletised cotton trash to manage groundwater recharge, and prevent salinisation, and improve soil carbon stores.
- Monitor the impact of the woodlot and cotton waste material on soil quality, salinity and groundwater levels

- Prepare site for establishment of trial at "Hudson", near Willow Tree, NSW
- Conduct GPS and EM-38 surveys to identify site variability and layout field plots
- Sample soils for baseline soil characterisation in winter 2002, followed by second sampling in Autumn 2003. Complete soil analyses.
- Plant Saltgrow Eucalypts in Spring 2002

OVERVIEW & OUTCOMES

Baseline soil sampling and field mapping of the experimental site were completed by July and experimental plots laid out by August. The soil analyses showed that the site was very saline and sodic. Because of drought and extreme salinity, planting of trees and application of composted gin trash was deferred until autumn 2003. Following this, because of possible contamination with pesticides through composted gin trash application, the Environmental Protection Agency of NSW expressed concerns on its use as a soil ameliorant. Consequently the use of gin trash has been deferred. Alternative sources of composted green-waste may allow the project to recommence next year.

Program Four Overview
Education And Technology Transfer.

Program Four Leaders Dallas Gibb, NSW Agriculture and Geoff McIntyre, Queensland Department of Primary Industries.

The adoption of Cotton CRC research outcomes is vitally important to promote a sustainable cotton industry. The utilisation and application of the research is an integral part of the Cotton CRC strategic plan. The commercial benefit of the research flows to the growers, the region and to Australia through increased productivity and fibre quality; regional development; sustaining the base and the environment; reduction in the use of pesticides; and increased export earnings.

The strategic objectives of the program through the three sub programs are to:

- Increase the industry skills base through the provision of high quality undergraduates and post graduates for the agricultural and research communities;
- Facilitate the widespread adoption of sustainable management practices through the extension team;
- Provide proactive information services through the Technology Resource Centre and the development and delivery of new technology in a range of decision support systems.

Thus contributing to an improved image for the cotton industry, which is regarded as being a responsible corporate and community citizen, ensuring its long term viability and sustainability.

Key Achievement.

Integrated Pest Management led to a 65% Reduction in pesticide use by Cotton Growers

Insect pest control is a major cost to cotton production. Reducing insecticide use has significant benefits to growers, the community and the environment. During the mid to late 1990's conventional cotton crops received an average of 11 sprays per season at a cost of $500 to $800 per hectare. This was unsustainable. Growers operated in isolation from each other in managing insect pests and this limited the adoption of integrated pest management (IPM) strategies and increased the development of insect resistance to pesticides. Outcomes from research and extension programs lead and coordinated by the Australian Cotton CRC have allowed cotton growers to gain confidence in IPM approaches and to significantly reduce pesticide use providing benefits to the broader environment and community.

Development of the IPM Guidelines by Cotton CRC researchers, the advent of Bt cotton and the clear field evidence for the value of beneficial insects has produced comprehensive strategies for IPM. The coordinated extension and education programs within the Cotton CRC have seen the rapid adoption of these strategies by growers, supported by sophisticated decision support tools. The first edition of the IPM guidelines was released in 1999. 93% of growers are now aware of the guidelines with 76% indicating that they have changed their management approach to insect pest as a result.
Coinciding with the release of the IPM guidelines growers began to work within groups to develop regional insect control strategies, an area wide management approach. These groups plant crops to trap pests as well

as attract beneficial insects. They also coordinate insecticide usage across a region to minimise the use of insecticides that are disruptive to beneficial insects. 84% of growers are now aware of the area wide management concept with groups operating in all cotton growing regions.

Through participatory learning growers have been able to reduce their use of insecticide and improve farm profits. The amount of insecticide applied in 2002 was 65% less in conventional cotton fields and 80% less in genetically modified (Bt Cotton) cotton fields compared to the late 1990's. Today 50% of growers rarely if ever spray for thrips. This is a 100% increase since 1997. Grower surveys indicate that the majority of growers now consider the conservation of beneficial insects extremely important and 69% use plant monitoring to improve pest management decisions. The benefits of this reduction in pesticide use flow through to local communities and the environment.

Key Success Factors include;

- Growers involved in area wide management groups that coordinate regional pest management activities
- Increased use of natural pest control techniques including beneficial insects
- Increased use of selective insecticides that are less harmful to beneficial insects
- Reduced overall insecticide use.

Impacts include a reduction in;

- Insect control costs
- Level of pesticides in the environment
- Spray drift complaints by local communities
- Off site contamination of pesticides

Cotton CRC contributions

- New IPM tools and strategies
- Coordinated extension across all cotton districts
- Facilitation of grower groups
- Establishment of grower focused short course in IPM
- Development of decision support packages (ENTOpak , CottonLOGIC)
- Development of CottonLOGIC for the handheld Palm OS

Key Achievement

Best Management Practice for Irrigation increased Water Use Efficiency by 10%.

Through an industry partnership, the Cotton CRC and Queensland Department of Primary Industries established the Rural Water Use Efficiency (RWUE) extension project titled " Cotton and Grains Adoption Program". The project was one of four developed within the Queensland Government Rural Water Use Efficiency Initiative (RWUEI) program. A total of $5.1 million was invested in the project between July 1999 to June 2003.

The key objectives of this 'Adoption Program' was to increase by June 2003, irrigation efficiency in the irrigated cotton and grain industries of Queensland by at least 10% and have 70% of growers adopting Best Management Practice guidelines for irrigation, which were to be developed during the program.

The Program's projected gains at the commencement of the RWUEI, estimated that an increase in efficiency by 10% would, for cotton, equal a return of $58 million for $5.1 million invested in the Program ($2.9 million from RWUEI + $2.2 million in-kind from QDPI). This was expected to lead to a benefit of $870 million to the State's economy. The indicative target set for the cotton and grains industries at the commencement of the Program indicated a saving of 60,000 megalitres (ML) of water.

The Program exceeded the target objectives by the end of the 2001/2002 summer. Water use efficiency as bales of cotton produced per ML of irrigation water used had risen 12.8% over the previous season, saving 67,855 ML across the State.

Water saved	67,855 ML
Improvement in bales/ML	12.8%

This saving provides the capacity for the production of 113,996 extra bales of cotton with a value of $57 million (at $500/bale).

Key success factors include:

- Skilled and coordinated extension team working in a strong partnership with irrigators and consultants;
- Implementation of effective demonstration trials in collaboration with irrigator groups;
- Irrigator adoption of water metering and irrigation scheduling systems;
- Irrigator modification of irrigation management strategies and system design;
- An outstanding response to the Financial Incentives Scheme (FIS) helped irrigators implement those changes to their management necessary to achieve Best Practice. $1.7 million of incentives have been contributed towards the purchase of goods and services totalling more than $4.3 million. This represents a total contribution by growers of 1.5 times the incentives contribution

Impacts:

- Improved irrigation water use efficiency;
- Reduced deep drainage;
- Reduced runoff of contaminated tailwater into rivers and streams.

Cotton CRC contribution:

- Leadership and facilitation of industry partnership with Cotton Australia and Agforce, irrigators and consultants;
- Coordinated extension program supporting demonstration trials;
- Training workshops;
- Contribution to the development of BMP guidelines for irrigation management in collaboration with Cotton Australia.

EDUCATION AND TRAINING

In developing a farming systems approach to crop production growers are required to integrate all aspects of crop growth, pest and disease control and natural resource management. Developing solutions to one problem in isolation to other components in the farming system limits a grower's capacity to achieve long term sustainability.

Education and training services provided by the Cotton CRC have been enhanced to reflect the need for an integrated farming system approach to production. Growers focused short courses have become a recognised platform to engage growers. Complex approaches to production and natural resource management can be promoted through these courses using participatory and action learning methodologies. The Cotton CRC 'IPM Short Course' which has received praise from the industry is an example of this new approach to technology transfer. A short course in water and irrigation management have also been piloted in 2003 and will be promoted across the industry in 2004. At a higher level, Unit 4 within the Cotton CRC Graduate and Undergraduate Certificate Course titled 'Cotton Farming Systems' has been redesigned to provide graduates with skills in systems interaction.

The scientific exchange program in 2003 saw a number of researchers travel overseas to expand their knowledge in integrated system approaches to production. A number of summer scholarship and post graduate student projects targeted cotton farming systems in 2003. Targeted training workshops in farming systems have also been conducted for front line extension staff.

A key aspect contributing to the success of educational programs in farming systems is the development of decision support packages that allow growers to conduct risk assessments for both tactical and strategic decisions. Training of extension staff in such packages is regularly conducted so that they are able is assist growers use such packages.

The most significant change that has occurred in cotton production systems over the last three years is the development and consolidation of 'Area Wide Management' groups. In adopting an area wide management approach growers work together to manage complex problem and more importantly they consider off-farm impacts of individual practices. Together with training in integrated farming systems, area wide management groups will provide a avenue for a coordinated approach to complex environmental issues such as vegetation and biodiversity management. Extension staff receive training in group facilitation and dynamics to support growers involved in area wide management groups.

Education and Training Services in Integrated Farming Systems

Aims and objectives

- Provision to industry of highly proficient consultants and agronomic management staff through continuation of certificate and post graduate certificate course in Cotton Production.
- Consultants fully accredited and participating in regular refresher courses.
- Cotton Production Certificate course being delivered to Australian and international Universities and students.
- Growers implementing farming systems using advanced management strategies learned from focussed short courses.
- Encouragement of high quality undergraduates to remain in agriculture through undergraduate and summer scholarships.
- Co-ordinated exchange program for industry researchers, extension officers and consultants operating within strong international networks.

Highlights and Achievements against milestones

Education – specialised short courses.
The nationally Farmbi$ accredited "IPM" short course has proved very popular with growers. 66 growers and consultants attended the course in 2002/3. The objective is to have 100 growers completing the course each year. The course has a focus on the implementation of IPM strategies for insect control and will link with the Industry 'Best Management Practice' (BMP) program. Consistent feedback from participants indicates that the course is both informative and practical.

The CRC water management extension and research team have developed a training course in water management (Furrow Irrigation). The course follows on from the 'WaterWise' training programs developed within NSW Agriculture. It will be delivered as an accredited course in both NSW and Queensland in 2004. To support the course, new management guidelines have been developed in the form a written material, 'WaterPak' and computer decision support system 'HydroLOGIC'.

Post Graduate Scholarships
See Table on Right.

Summer Scholarships
The summer scholarship program proved highly successful during the 2002/2003 cotton season. The students covered a diverse range of subjects including:

- Compensation from boll damage by mirids;
- Evaluation wet season cover crops as potential nurseries for insects in the Ord River Irrigation Area;
- Developing Deep Drainage Risk Maps for the Macintyre Valley;
- Viability of insect-borne cotton and canola pollen;
- Sampling methods for pest and predator abundance in cotton.

Scientific Exchange Program
To enhance the exchange of ideas, the gathering of innovative technology or practices and overseas collaboration, the Cotton CRC sponsored four overseas trips/visits during the 2002/2003. They included:-

- Attendance at the 'Integrated Biological Systems Conference' in Texas;
- Attendance at the '19th Annual Conference of the International Society of Chemical Ecology' Hamburg;
- Assessment of Farming Systems in the United States;
- Attendance at the 'International Congress on Irrigation and Drainage'.
  This year the Cotton CRC and CRDC also contributed funds to assist some 25 Australian researchers to attend the 3rd World Cotton Research conference held in Cape Town South Africa in March.

Information Delivery and Decision Support
Success of technology transfer is dependent on the rapid distribution of research outcomes to growers. To achieve this, researcher and extension staff work together to develop a range of written and computer based decision support systems. To make these systems readily available to growers, a number are available on the CRC Website.

In developing decision support systems links are made to the industry BMP program and training programs. They form a vital resource for extension staff in the development of national extension activities.

To further advance the delivery of field based decision support systems and data collection, researchers have utilised handheld Palm OS pilot technology. The use of this technology is believed to be a world first for agricultural sector. Consultants and growers can now record farm practices and use a range of computer decision support systems anywhere in the field.

Advances in the user-friendly crop simulation model, OZCOT continued throughout 2002/03. The model has been incorporated into the HydroLOGIC decision support system that will be release to growers in late 2003. It provides an important extension tool in aspects water management allowing growers to run a range of simulations to assist in risk management. It was used extensively during 2003 to assist grower manage irrigations during the drought.

A range of decision support packages have been developed over the last 3 years. These include SOILpak, NUTRIpak, ENTOpak and MACHINEpak. Three new information packages SPRAYpak, WEEDpak and Disease Management Guidelines were released in late 2002. In 2003 new IPM guidelines and WATERpak will be released.

The objective of these packages is to provide growers and consultants with management guidelines for all key aspects of cotton production. They represent a collation of research outcomes. Although the packages provide a useful reference material, searching for specific information quickly remains difficult. To solve this problem and to improve the management of information provided in these packages, the CRC Technology Resource Centre developed the innovative COTTONpak CD. This CD enables growers to search all the packages quickly. It also allows linkages between management guidelines to be made so the whole farm management systems can be developed. The CD provides cost effective delivery of information to growers and will be enhanced during 2004 to include video segments and website links.

Cotton CRC Post Graduate Students

Student	Degree		Research Project Title/Thesis	University	Supervisors	Org	Funding	Current Status
Janelle Montgomery	PhD	21-Aug-95	Water application and hydrology	UNE	Assoc. Prof. Don MacLeod, Dr Richard Faulkner	UNE	Cotton CRC	Due October 2003
Emma Louise Cottage	PhD	1-Feb-98	Management of resistance in Bemisia tabaci to insect growth regulators and juvenile hormone mimics	UNE	Assoc. Prof. Peter Gregg, Dr Robin Gunning	UNE	CRDC	Accepted January 2003
Constanza Angelucci	PhD	1-Feb-98	Binding sites for the Cry1Ac delta-endotoxin of Bacillus thuringiensis in *Helicoverpa*	ANU	Dr Ray Akhurst	CSIRO Ento	CRDC Ento	Due September 2003
Fiona Frances Ballard	PhD	1-Mar-99	Identification and characterisation of genes for resistance to bacterial blight in the cotton plant.	USYD	Dr Bruce Lyon	USYD	CRDC	Due January 2004.
Dave Britton	PhD	1-Aug-99	Studies of slow release formulations for semiochemicals in cotton pest management	UNE	Assoc. Prof. Peter Gregg	UNE	CRDC	Due January 2003
Sevag Bedrossian	PhD	1-Jan-00	Potassium Status and Mineralogy of Soil in relation to premature senescence in cotton in Northern NSW	USYD	Dr Balwant Singh, Dr Ian Rochester	USYD	CRDC	Due submit 31 March 2004
Andrew Davies	PhD	14-Feb-00	Ecology of the Trichogramma egg parasites in the Ord River Irrigation Area and their role in cotton IPM	UQ	Prof Myron Zalucki, Dr Gary Fitt, Geoff Strickland	UQ, QDPI, CSD	CRDC	Due to submit 2003
Mark Wade	PhD	28-Feb-00	Biology, ecology and utilisation of the Damsel Bug as a predator in cotton - towards real IPM	UQ	Prof. Myron Zalucki, Dr Bernie Frazmann	UQ	CRDC	Due December 2003
Lisa Gulino	PhD	1-Jul-00	Molecular diagnosis of Fusarium wilt of cotton in Australia	UQ	Dr Suzy Bentley, Dr Joe Kochman, Dr Steve Allen	UQ, QDPI, CSD	Cotton CRC	Due June 2004
Adam Downey	PhD	1-Jul-00	The effects of cotton defoliants on native trees from north western NSW field based experiments.	UNE	Dr John Duggin, Mr Guy Roth	UNE CRDC	Cotton CRC	Due June 2004
Michael Zuckermann	Masters	1-Jul-00	Protease resistant insecticidal proteins for controlling *Helicoverpa* species	ANU	Dr Ray Akhurst	CSIRO ENTO	CRDC	Masters completed 2003
Erica Crone	PhD	15-Mar-99	Characterisation of a potential new insecticidal transgene.	ANU	Dr John Oakeshott	CSIRO ENTO	CRDC	Due June2003
Florian Yan	PhD	1-Jul-00	Cotton Soil Health: influence on cotton root diseases	USYD	Dr Les Copland, Dr Tony Vancov, Dr David Nehl, Dr David Backhouse.	USYD, NSW Ag, UNE	Cotton CRC	Due June 2004
Sven Delaney	PhD	1-Feb-01	Development of gene promoters for cotton fibre development.	UA	Dr Sharon Orford	UA	CRDC	Due December 2003
John Harvey	PhD	1-Feb-01	Diversity and pathogenicity of Thielaviopsis basicola. (Black Root Rot).	UQ	Dr Elizabeth Aitken, Dr David Nehl	UQ	Cotton CRC	Due January 2004.
Samuel Lower	PhD	1-Jan-01	Pheromones for occasional pests of Cotton.	UNE	Assoc. Prof. Peter Gregg Dr Alice del Socorro	UNE	Cotton CRC	Due June 2004
Rose Roche	PhD	1-Jul-01	Training in crop physiology - Functional responses of cotton to environment mediated via internal nitrogen dynamics.	UQ	Dr Michael Bange	CSIRO PI	CRDC	Due June 2004
Amanda Cleary	PhD	1-Aug-01	The effect of cereal stubble on Helicoverpa activity in early season cotton.	QDPI	Dr David Murray	QDPI	CRDC	Due August 2004
Ingrid Rencken	PhD	1-Jan-02	Role of Native vegetation in harboring beneficial insects and reducing insect pest damage in cotton.	UNE	Assoc. Prof. Nick Reid, Assoc. Prof. Peter Gregg, Dr Letitia Silberbaurer	UNE	Cotton CRC	Due April 2005.
Richard Kent	PhD	1-Jan-02	The role of weeds as alternative hosts of Fusarium wilt in cotton.	UNE	Dr Brian Sindel Dr David Beckhouse	UNE	Cotton CRC	Due December 2004.
Sam Buchanan	PhD	1-Jan-02	Hydrological impacts of irrigation in the Bourke district.	USYD	Dr John Triantafilis	USYD	CRDC	Due December 2004

Saara Kate Bowen	PhD	1-Jan-02	Molecular analysis and manipulation of terpene biosynthesis in cotton.	ANU	Dr Danny Llewwllyn	CSIRO PI	CRDC	Due October 2005
Adam Loch	PhD	1-Feb-02	Estimating the impacts of Best Management Practices on public values for environmental tradeoffs in the Fitzroy Basin.	UCQ	Dr Colin Rolfe	UCQ	CRDC	Due December 2003
John Humphries	PhD	1-Feb-02	Analysis of TTG1 homologues in cotton for roles in fibre initiation.	UA	Assoc. Prof. Jeremy Timmis	UA	CRDC	Due February 2005
Christina Hall	PhD	1-Mar-02	Defence mechanisms of cotton against Fusarium oxysporum f.sp. Vasinfectum and control of fusarium wilt.	UM	Assoc. Prof. David Guest	UM	CRDC	Due December 2004
Damien Lightfoot	PhD	1-Mar-02	Fibre improvement through modulation of transitions in cotton development.	UA	Assoc. Prof. Jeremy Timmis	UA	CRDC	Due February 2005
Adriane Machado	PhD	1-Jul-02	Gene discovery in cotton fibre initiation and development by comparing cotton lintless mutants to wild type on cotton ovule cDNA microarrays.	ANU	Dr Elizabeth Dennis	CSIRO PI	CRDC	Due June 2005.
Simon Speirs	PhD	1-Oct-01	Characterizing soil structure stability and form of sodic soil used for cotton production.	USYD	Dr Stephen Cattle Dr Nilantha Hulugalle	USYD NSW Ag	Cotton CRC	Due October 2004.
Mick Rose	PhD	1-Mar-03	The environmental benefits of constructed wetlands on cotton farms: pesticide remediation.	USYD	Prof. Ivan Kennedy	USYD	Cotton CRC	Due June 2005
Karen Ivkovic	PhD	1-Sep-02	Development of a decision support system for water allocation in the Gwydir and Namoi Valleys.	ANU	Dr Rebecca Letcher	ANU	CRDC	Due March 2006
Stella Loke	PhD	1-Jan-03	Diversity of VAM fungi in soil health.	USYD	Dr Peter McGee	USYD	CRDC	Due December 2005
Leah Mackinnon	Masters	1-Jan-03	The biology of insectivorous bats, as predators of pests in cotton fields, and associated woodland or forest remnants.	USYD (Orange)	Dr David Goldney	USYD (Orange)	CRDC	Due June 2004
Derek Collinge	PhD	1-Jan-03	Gene silencing technologies to control *Helicoverpa* armigera.	ANU	Dr Steve Whyard Dr Carolyn Behm	CSIRO ANU	CRDC	Due February 2006
Jeff Werth	PhD	1-Jan-03	Weed resistance modellling for glyphosate tolerant cotton	UA	Grant Roberts, Dr C Preston	UNADEL	Cotton CRC	Due December 2005
Leonie Whiffen	PhD	1-Mar-03	Sequestration of carbon below ground by arbuscular mycorrhizal fungi and cotton roots	USYD	Dr David Nehl, Dr Peter McGee	NSW AG, USYD	Cotton CRC	Due June 2005.
Chris Vanags	PhD	1-Mar-03	Hydrologic and geophysical characterisation of Palaeochannels in Northern NSW	USYD	Dr Willem Vervoort	USYD	Cotton CRC	Due March 2006
Tim Weaver	PhD	1-Nov-00	Soil Physics and Chemistry: Movement of Nutrients in Vertisols/Drainage in Vertisols	University of Griffith	Hossein Ghadiri	Uni of Griffith, NSW Ag	Cotton CRC	Due March 2004

EXTENSION AND ADOPTION – Demonstrating technology to growers.

Effective extension programs are being, and will continue to be developed to communicate research findings to individual cotton growers and to industry. A network of regional Industry Development Officers (IDOs) participates in a range of activities in collaboration with grower, consultants and agribusiness.

David Kelly Industry development Officer Emerald working with growers in the east Wogoa Area Wide Management group.

Aims and objectives

The provision of a coordinated national extension service to the Australian cotton industry using modern techniques and delivery systems and working in partnership with growers and consultants to demonstrate, adapt and adopt new technology by:

- Expanding and enhancing the national cotton extension service within the industry;
- Promoting on-farm demonstrations and field trials with strong grower and consultant participation;
- Establishing grower based Integrated Pest Management (IPM) and Area Wide Management (AWM) support groups;
- Examining social barriers to technology adoption.

Highlights and Achievements

The extension and adoption process established by the CRC Sustainable Cotton Production continues to provide an excellent foundation for the development of a cohesive, well-focused and coordinated extension team.

Achievements:

- The National Cotton Extension Coordinator (NCEC), Ingrid Christiansen, commenced duties in March 2001.

- The cotton extension team, which includes extension officers in NSW Agriculture, DPIQ and CRDC, has a national focus on major industry issues and a prioritised list of regional problems. The Cotton CRC has funded two officers in the extension team and provides the leadership and coordination of a team which now includes:
    - Ten Industry Development Extension Officers (IDOs), one trainee and five Water Use Efficiency extension officers located strategically throughout the industry;
    - One Extension Technical Officer;
    - Five farming systems extension officers and five irrigation extension officers in NSW Agriculture and DPIQ who contribute part of their time to cotton industry extension activities;
    - Two spray application development extension officers;
    - The IPM Training Coordinator.

- Extension team activities include:
    - On farm trials and demonstration trials in collaboration with growers and consultants;
    - Establishment and facilitation of grower groups participating in the adoption of IPM and Area Wide Management (AWM) and other issues including Best Management Practice and water management;
    - Annual review and planning workshops;
    - Industry wide benchmarking studies;
    - Evaluation of extension activities.

The CRC Cotton Extension Committee comprising Dallas Gibb, NSW Agriculture (NSW Ag), Geoff McIntyre, Department of Primary Industries Queensland (DPIQ), Bruce Pyke and Adam Kay, Cotton Research and Development Corporation (CRDC) and Glen Fresser, Australian Cotton Growers Research Association (ACGRA) provides leadership of the extension team.

The NCEC has ensured a coordinated focus on national extension priorities and the development and implementation of the most effective delivery methods. The development of training opportunities for extension officers and the establishment of industry wide linkages are key objectives for the coordinator.

The team has maintained five focus groups that are responsible for identifying and prioritising national issues and planning and resourcing nationally focussed extension programs. They are:

- Farming Systems;
- Disease and Weeds Management
- Environment;
- Insect Management;
- Water Use Efficiency.

The IDOs work closely with regional grower associations and maintain strong links with all research programs.

An annual cotton extension planning workshop provides the opportunity for the extension team, researchers and consultants to identify and prioritise national issues. Technical training has been undertaken in other workshops during the season.

Implementation of strategies for IPM and AWM of insects continues as a high priority for the extension team with a program focussed on the establishment of IPM and AWM grower groups and the application of the IPM pest management guidelines. It is supported by the IPM Training Coordinator who has developed a grower focussed training program and delivered six short courses with local assistance provided by the IDOs. The project undertaking the economic assessment of IPM and Insecticide Resistance Management (IRM) strategies is an important resource support. This assessment, based on data sets from IPM grower groups during recent seasons, has demonstrated conclusively that fewer insect sprays can be associated with higher profit margins whilst deriving significant environmental benefits.

The Cotton CRC has continued the cotton and grains project that is part of the Rural Water Use Efficiency Initiative of the Department of Natural Resources and Mines in Queensland.

Its objective is to improve water use efficiency in the cotton and grains industries in Queensland. This four-year program provides for an adoption project managed and delivered by the project coordinator and five extension officers in DPIQ, and has been extended until the end of 2003. The CRC has continued to ensure the maintenance of effective linkages with a similar NSW Agriculture initiative.

The IDOs have provided significant contributions to the NUTRIpak, DISEASEpak and WEEDpak publications which are due for release to the industry and will be involved in the development of WATERpak in the next year.

The extension team has supported Cotton Australia and growers in the implementation of the industry Best Management Practice (BMP) program by providing technical resource support for growers developing and implementing management plans. Cotton Australia BMP facilitators and area managers manage the process and auditing procedures. BMP provides an effective vehicle for the delivery of new and advanced technical information and management strategies.

IDOs have continued to respond to a number of issues demonstrating the capacity of the extension team to address emerging industry needs in a timely manner.

The extension programs are primarily directed to industry clients – growers, consultants and agribusiness. However, IDOs also contribute significant support to community and environmental groups in the course of their normal activities and as members and participants in their regional communities. They provide information through regional publications and media outlets, as members of community groups and by participating in educational activities often in collaboration with Cotton Australia.

Liaison and communication with the broader community and environmental groups at a national level is a primary function of Cotton Australia and includes activities coordinated by the Cotton CRC.

Linkages

Personnel in the Technology Resource Centre, CRDC, Cotton Australia (CA), Cotton Consultants Association, Cotton Seed Distributors and Deltapine Australia collaborate with and contribute to extension team activities.

The extension team has direct linkages with ACGRA nationally through the ACGRA Chairman and the Research Committee chairpersons who link directly with each of the focus teams. Regionally, all extension officers are active participants in the regional Cotton Grower Association and their RD&E sub-committees.

The IDOs collaborate with all research officers to ensure strong linkages between the CRC research and extension programs and with researchers in many other research organisations in NSW and Queensland.

CRDC extension projects included in the extension team program are:

DAN 167C	Cotton Industry Development Officer, Lower Namoi
DAN 168C	Cotton Industry Development Officer, Upper Namoi
DAN 167C	Cotton Industry Development Officer, Macquarie
DAQ 100C	Extension Agronomy for Cotton Production in CQ
DAQ 114C	Cotton Industry Development Extension Officer – Border Rivers
DAQ 115C	Cotton Industry Development Extension Officer – Dirranbandi and St.George
DAQ 98C	Improved pesticide application performance.

Project Summaries

PROJECT NUMBER: **4.1.02 AC**

PROJECT TITLE: **Graduate Certificate in Rural Science (Cotton Production) and Undergraduate Certificate in Agriculture (Cotton Production)**

STAFF:
Dr John Stanley, University of New England, Armidale.
A/Prof Robin Jessop, University of New England. NSW.

AIMS & MILESTONES:
The aim of this project is to design, review and run the only specialised university cotton training course in Australia for industry personnel including consultants, advisors, farmers and students.

OVERVIEW & OUTCOMES:
The Applied Cotton Production Course, delivered though the University of New England, continues to attract a strong intake of students. Most students complete the course over two years choosing to do one unit per semester (half year). Those units are: Cotton Production, Cotton Protection, Cotton and the Environment and Cotton Farming Systems. Approximately 30 Industry personnel deliver highly relevant seminars and practical sessions in four residential schools supporting the four externally offered units comprising the Cotton Production Certificates.

This, the only University level cotton course in Australia, continues to support the education requirements of the cotton industry, attracting cotton growers, consultants and trainee agronomists, along with many service industry and research staff. 133 students have so far graduated from the course

either at the Graduate or undergraduate levels. This year, another 21 students graduated. The applied cotton production unit was also delivered at the University of Sydney and the University of Queensland (Gatton campus) via 2-3 day workshops delivered by the Cotton CRC course coordinator.

Education - certificate course

The number of new enrolments and graduates for both the postgraduate and certificate course continues to grow. A total of 27 students were admitted in 2003 and 21 students graduated from the course in April 2003 bringing total graduates to 133. There has been a steady increase in the proportion of people enrolling at the certificate level, which is encouraging and reflects the capacity of the course to meet the needs of those in the industry without any formal qualifications.

The course continues to be popular as an undergraduate elective "Applied Cotton Production" with 62 students enrolled in 2003. Proving successful across a number of Universities, 46 of the undergraduate students where located at Universities other than the University of New England.

The final unit within the course "Cotton Production Systems" has a focus on putting in to practise what has been learnt throughout the course. It involves farm case studies, grower implementation of BMP guidelines, area wide management strategies, risk management and marketing.

A business plan was completed for the course in 2003 to provide direction beyond the life of the CRC. Recommendations include the development of targeted courses for service industries and overseas research and extension staff. Sensitivity analysis of student fees indicated that to remain attractive to external students only a marginal increase would be possible.

Students examining cotton at the Narrabri field trip.

Students examining cotton at the Narrabri field trip.

PROJECT NUMBER: **4.2.00 AC**

PROJECT TITLE: **Extension Technical Officer - Dalby**

STAFF:

Greg Salmond, QDPI, Dalby, QLD.
Jenelle Hare, QDPI, Dalby, QLD

AIMS & MILESTONES:

The Extension Technical Officer - Dalby contributes to the network of regional industry development officers by:

- The promotion of on-farm demonstration and field trials with strong grower and consultant participation;
- Support of grower based IPM and Best Management Practice grower groups;
- Participation in extension development groups of growers, consultants, growers associations, consultants, research and extension agronomists, in planning activities and setting priorities;
- Collaboration with researchers and peers to generate information materials such as booklets and information packages for use in extension projects and self help centres.

As a member of the Australian Cotton CRC's National Extension Team, Ms Hare, participates in programs that result in the continuous improvement of management practices and broad community recognition.

OVERVIEW & OUTCOMES:

Ms Hare has made a significant contribution to the operations and management of the CRC's Farming Systems Trials at Warra and Mywybilla. She took a lead role in the establishment of the districts Bollgard II® - Fruiting Factor Trials, and provided technical support for other CRC/CRDC supported projects on the Darling Downs.

Ms Hare continues to maintain weather data from the

eighteen grower-owned weather station network on the Darling Downs. She has continued her close liaison with members of the Darling Downs Cotton Growers Association Inc Management Committee, and has provided weather data files to industry and researchers. The demand for this information continues to increase. Ms Hare produced and distributed a weekly newsletter – "Weather or Not", during season 2002/03. It has been distributed to the Cotton Consultants Association network based on the Darling Downs. Feedback from this activity continues to be extremely positive, and the information eg day degrees, cold shock temperatures, is highly valued by the consultants for their management decisions.

PROJECT NUMBER: **4.2.02 AC**

PROJECT TITLE: **Improving on farm water use efficiency in the Queensland cotton and grain industries**

STAFF:

Dr Phil Goyne, QDPI, Warwick, QLD.
Geoff McIntyre, QDPI, Dalby, QLD
Graham Harris, QDPI, Toowoomba, QLD
John Okello-Okanya, QDPI, Emerald, QLD
Andres Spragge, QDPI, Dalby, QLD.
Sarah Hood, QDPI, St George, QLD
David Wigginton, QDPI, Biloela, QLD
Olivia Whiteoak, QDPI, Goondiwindi, QLD
Toni Anderson, QDPI, Emerald, QLD

AIMS & MILESTONES:

The objective of the project is to increase irrigation efficiency (IE) in the cotton and grain Industries by at least 10% and have 70% of cotton and grain irrigators adopting Best Management Practice (BMP) guidelines which will be developed for general application for the irrigation of all crops.

The aim is to increase crop production per megalitre of water used (CWUE) to1.1 bale/Ml for cotton and to improve CWUE in grain crops by 10%. As irrigators grow both cotton and grain crops in the irrigated farming systems of the major irrigated cropping areas, the project will address irrigation water use efficiency of all field crops such that the benefits will be combined.

Field demonstration programs developed and improved practices identified.

- Review of draft BMP water module complete
  Regional irrigators involved in discussion of WUE and best practice through participatory action double loop learning groups
- Training programs delivered
  Training programs implemented
  Awards presented in each region
- Year 4 demonstration sites completed
  Participatory action learning groups (BMP, IPM) conducted with irrigators within regions to discuss issues relating to better water use
  Results of demonstration sites analysed by groups
- Project Reviewed and reported
  Report on performance against Milestones approved by DNR
- Adoption program activities and outcomes evaluated
  Levels of awareness-85% and participation - 70% of growers
  Levels of adoption of BMP - 70 % growers
- Final evaluation and reports completed
  Final reports submitted.

OVERVIEW & OUTCOMES:

This project is being conducted within the Queensland Government's Rural Water Use Efficiency Initiative (RWUEI) as the Cotton and Grains Adoption Program by The Australian Cotton CRC through QDPI. The objective is to increase irrigation efficiency in the cotton and grain

The Water Use Efficiency team took out the environmental section of the Primary Industries Week Achievement Award. Left:- The Cotton CRC's Queensland Water Use Efficiency team accepting their award from left to right: - Steve Ginns - Trainee IDO Emerald, Wayne Parr NIASA (Nursery Industry Accreditation Scheme of Australia), Phil Goyne WUF Team Leader, Sarah Hood IDO St George, David Widdinton IDO Biloela, Olivia Whiteoak IDO Goondiwindi, Andres Spragge IDO Dalby and Toni Anderson IDO Emerald.

industries by at least 10% and have 70% of growers adopting Best Management Practice guidelines, by June 2003.

The project is now firmly established in the five target regions (St George/Dirranbandi, Goondiwindi-Macintyre Valley, Darling Downs, Callide/Dawson, Emerald and Mackenzie/ Fitzroy), awareness of the project has increased, grower management groups have been actively involved and irrigation benchmark data have been collected from the demonstration sites in both cotton and grain crops.

It has been the task of the Cotton/Grains team to monitor grower irrigation management, to establish initial benchmarks on irrigation and water use efficiency and to determine where efficiencies can be improved. In addition the team has been actively promoting the RWUEI Financial Incentives Scheme that supports the purchase of equipment to improve irrigation efficiency. The team has also established an Irrigator Awards Scheme in the regions to reward co-operators and innovative irrigators.

The Cotton/Grains Adoption team has contributed to the development of the Land and Water module for BMP which provides the framework for ongoing efficiency gains in irrigated production.

Andres Spragge Water Use Efficiency Team Technical Officer Dalby giving on-farm demonstrations to Dalby growers.

PROJECT NUMBER: **4.2.03 AC**

PROJECT TITLE: **Cotton Industry Development Officer – Gwydir**

STAFF:
Julie O'Halloran, NSW Agriculture, Moree, NSW
Russell Carty, NSW Agriculture, Moree, NSW.

AIMS & MILESTONES:
• To provide professional extension services to cotton growers in the Gwydir.

OVERVIEW & OUTCOME:
The main role of the Cotton Industry Development Officer is to provide extension of research outcomes to cotton growers in the Gwydir valley. Extension plans are developed as part of the National Cotton Extension Team and then adapted to include local issues. An early season meeting held with growers and consultants helped identify and prioritise local issues for extension. This was continued throughout the season through CCA meetings and grower meetings.

Area wide management groups continued to meet during the 2002/03 season. Preseason meetings focused on irrigation strategies given the limited water for the 2002/03 cotton season and Pesticide Application Management Plans in liaison with the Cotton Australia Grower Service Manager. Most in season meetings were focused on water and pest management. Activities included looking at a lateral move irrigator, growth management with Pix® applications and optimisation of furrow irrigation using modelling. Fusarium continues to be a concern.

The Cotton Tales newsletter was on a regular basis distributed throughout the 2002/03 cotton season. The newsletter presented research results and information updates on national and local cotton industry issues and was used to promote extension activities and meetings. Regular interviews with the 2VM radio station in Moree also helped with the promotion of extension activities and research.

The Gwydir Valley Cotton Field Day was well attended although field demonstrations were cancelled due to rain. An IPM short course was started with growers from the Gwydir valley in August 2002 and the final component held in May 2003. The local cotton crop competition was again held this year with a few changes due to the lack of dryland plantings.

Trials are carried out to address both national and local issues. Bollgard II® trials looked at the impact of different fruiting factors and fruit removal on yield, quality and nutrition of Bollgard II®. A Trichogramma release was carried out as an IPM approach to pest management in sensitive areas.

Key outcomes during the year included;

- Increased awareness and confidence in IPM systems
- Greater understanding of management options for Fusarium wilt through grower meetings and promotion of IDM guidelines
- Increased awareness of tools to maximise water management

PROJECT NUMBER: **4.1.05 AC**

PROJECT TITLE: **IPM Training Coordinator**

STAFF:
Mark Hickman, NSW Agriculture, Gunnedah NSW

AIMS & MILESTONES:
The IPM short course program aims to develop:

- A comprehensive educational package, which clarifies the latest best practice for IPM as identified by industry experts (including growers).
- Economic links to IPM strategies, with the assistance of Australian Cotton CRC economists, within short, medium and longer-term timeframes.
- An extension program (including grower best practice groups) assisting growers to 'take responsibility' for management decisions, and emphasising economic sustainability rather than yield and linking this with the training program.

- Conduct between 7 - 8 IPM short courses for the 2002 /2003 season
- The reference manual will constantly be updated to reflect any further information and changes.
- Finalise negotiations and appointment of Registered Training Organisations (RTO) and finalise FarmBi$ subsidy requirements.
- Finalise assessment checklists for the course in conjunction with RTO's.
- Australian Cotton CRC appoint a commercial agent
- Produce flyers and further promote IPM short course.

OVERVIEW & OUTCOMES:
Integrated Pest Management (IPM) allows the cotton industry to control insects, diseases and weeds in a cost-effective, environmentally sound and socially acceptable way. IPM in cotton is about using a number of tactics to manage pests in a way that ensures the sustainability of the industry. It is not about 'organic' cotton nor is it easily implemented. IPM in cotton is based on many years of scientific research and adoption and is the accumulation of years of hard-earned experience. There is no IPM recipe for cotton production, rather an extensive array of tools that growers could adopt.

IPM may also include a change in attitudes to pest management to fully understand this complex and dynamic system. The need for a grower-focused short course in IPM was first highlighted in the third year review of the CRC for Sustainable Cotton Production.

The IPM short course now developed and piloted provides benefits to growers by providing a clear understanding of the science behind IPM and an opportunity to learn from the experiences of other growers. The course provides a forum for discussion, which challenges current industry thinking. Perceptions about IPM such as delayed maturity and low yields can be replaced by positive considerations of maintaining profitability and yield while reducing reliance on chemical control measures.

The current format of the course is 4 components. Component 1 is a two-day intensive information session with group activities. Components 2 and 3 are half day, "hands-on" field days during the season. This is coupled with group discussion about the implementation to management decisions. Component 4 is a review session. This allows each participant to report on their practice of IPM during the season.

During 2002-03 a total of 66 people attended the 6 courses held at Emerald, St George, Mungindi, Moree, Goondiwindi and Wee Waa. Of the courses completed, 85% of participants have reached the certificate attainment level.

Course evaluation by participants has been a focus of the 2002-03 courses. Participants consistently provide favourable comments about how the course was 'field based and practical'. Negative comments were few, although some growers found the pace of learning a little ' rushed in certain aspects' . Others found the course was perhaps 'too basic' for their needs. These comments highlight the range of learning styles and the dynamic level of knowledge that the clients bring to the course. The challenge is to meet the majority of grower needs. Continued support by researchers and industry personel will be essential for ongoing success of the short course.

Mark Hickman completing the half day hands-on field days which occur throughout the season.

Mungindi classroom - growers completing the IPM Short Course.

Moree Classroom - Moree growers completing the IPM Short Course.

PROJECT NUMBER: **4.2.05 AC**

PROJECT TITLE: **National Cotton Extension Coordinator**

STAFF:
Ingrid Christiansen, QDPI, Toowoomba, QLD

AIMS & MILESTONES:

- Develop a coordinated focus on national extension programs;
- To develop and facilitate best delivery methods;
- Facilitate extension training activities;
- Ensure participation of research scientists in these programs.

OVERVIEW & OUTCOMES:
The integration of research outcomes into on-farm management and public understanding is vital for the value of research investments to be realised.

The Cotton Extension Network aims to assist in development of sustainable farming systems through:

- Communication of research;
- Integration of research and industry knowledge into management recommendations;
- Providing forums for learning and communication;
- Building confidence in research through regional trials;
- Developing and providing educational programs; and
- Coordination of regional activities.

The National Cotton Extension Coordinator enhances the value gained from the investment in extension programs through nationally coordinated extension activities; developing skills of extension staff; liasing with industry to match program to key priorities; supporting well planned and targeted extension initiatives and evaluating outcomes.

Some key outcomes:

- A picture of preferred learning styles of industry is being drawn through evaluation of extension activities.
- Specialised technical and extension expertise is being developed in the extension network.
- Extension research projects have been negotiated and developed with new partners.
- Extension strategies have been developed for salinity and sodicity in response to priorities identified at the Farming Systems forum.
- The extension network and Information Resources provided by the Technology Resource Centre are highly valued by industry.

The Extension Team - Developing marketing approaches in extension - Extension Workshop 2002, Brisbane.

Industry Development Officers together with CCA representatives from each region received detailed training in spray application technology from Peter Hughes and Paul Kleinmeulman (both DPI/Cotton CRC), Bill Grodon (then C-PAS, UQ) and Graham Betts (ASK GB). Pictured at the training workshop at The University of Queensland, Gatton.

Lower Namoi Field Day.

Lower Namoi Field Day.

Left to Right Bob Aitken, BSES Harwood Penny van Dongen, Cotton IDO Upper Namoi and Kirrily Rourke Cotton IDO Macquarie discuss extension techniques for sodic soil management at a soils workshop conducted by Dr Nilantha Hulugalle at the Australian Cotton Research Institute in Narrabri May 2003.

PROJECT NUMBER: **4.2.07 AC**

PROJECT TITLE: **Evaluating economic implications of new management approaches in cotton**

STAFF:
Ziaul Hoque, NSW Agriculture, Narrabri, NSW
Bob Farquharson, NSW Agriculture, Tamworth, NSW
Martin Dillon, CSIRO Entomology, Narrabri, NSW
Dr Ian Taylor, NSW Agriculture, Narrabri, NSW

AIMS & MILESTONES:
Aims: To evaluate the economic implications of new management practices for cotton production, such as Integrated Pest management (IPM), weed management and farming systems.

- Study of economic benefits of IPM within the Boggabilla Area Wide Management (AWM) group for last 4 seasons, start from 1998/99 to 2001/02
- Economic analysis of Petroleum Oil Spray (PSO) trials with Dr Robert Mensah
- Economic evaluation of IRM (Insecticide Resistance Management) strategies within Australian cotton industry
- Economic cost of weeds in dryland cotton systems
- Economic analysis of other CRC projects

OVERVIEW & OUTCOMES:
The Beneficial Disruption Index (BDI) has been refined and a revised economic analysis of IPM has been conducted for three seasons since 1998/99. Data sets from the Boggabilla Landcare Group, of northwest NSW were used for this research. BDI allows spray regimes to be compared based on their disruptive effect on beneficial insects and financial returns. Fields were ranked as soft and hard based on their BDI score of the chemicals applied. Results indicate that for all three seasons, spray costs decreased and profits increased under 'Soft' management compared to 'Hard' distruptive strategies. The results also showed that higher yields do not automatically translate into higher profits.

However, results for conventional fields in 2000/2001 show that the trend does not always hold true. Conventional fields managed under a less disruptive approach, had lower yields and produced lower profits than Hard fields in that season. Compared with the earlier seasons, many of the insecticide sprays in 2000/2001 season were targeted to secondary pests (such as mirids and other sucking pests). In contrast to control options for *Helicoverpa*, there are no target-specific insecticides for sucking pests. The implications of this are that any insecticide spray directly targeting sucking pests will also disrupt beneficial insects, often substantially. Once beneficials are no longer abundant within a cotton field, it is likely that pests will reach economic threshold levels more often, chemical intervention is likely to be required more often. The BDI index has been widely used in the industry. Growers, consultants and the researchers are using the index to assess the spray regimes.

A study was conducted with dryland growers to evaluate the economic losses caused by weeds in dryland cotton systems based on 2000-2001 season. The average per hectare weed control costs is estimated to be $220 in northern NSW (comprising the Macquarie, Namoi and Gwydir river valleys), $220 in southern Queensland (centred on the Darling Downs) and $124 in central Queensland (based on Emerald and the Fitzroy area). Average cost for weed management in summer and winter fallows is $34.40 per hectare in 2001. The aggregated financial costs (control cost and yield loss) of weeds in dryland cotton to producers is estimated to be $25 million for these three regions.

An economic surplus model was used to assess the broader cost associated with weed control by estimating the direct and indirect cost such as the cost of other industry players (eg processors, manufacturers) and consumers. The total economic cost of $41 million can be compared with $25 million of on-farm financial costs.

Analysis of Petroleum Oil Spray trials showed that cotton could be grown profitably spraying Petroleum Oil Spray compared to conventional sprays.

PROJECT NUMBER: **4.3.00 AC**

PROJECT TITLE: **Cotton Technology Resource Centre**

STAFF:

David Larsen, NSW Agriculture, Narrabri, NSW

AIMS & MILESTONES:
The TRC aims to service the Australian cotton industries' extension material requirements, both paper based and electronic. It assists researchers in the timely production and distribution of research based material. It also provides support for the cottonLOGIC program.

(i) Maintain industry database/mailing/fax list as an integral part of information distribution to the industry.
(ii) Visit all growing regions to promote the Technology resource centre and its products and to collect feedback.
(iii) Continue to provide distribution and technical support for decision support packages.
(iv) Produce material in response to special industry needs.
(v) Maintain Cotton CRC internet site.
(vi) Continue operation of centre including responding

to individual growers and consultant queries and maintain responsibility for distribution of material including CottonLOGIC.

OVERVIEW & OUTCOMES:

The Australian Cotton CRC Technology Resource Centre continues to serve the industry with extension material. The TRC assists researchers in producing and distributing research based material in a timely manner as well as giving support for the CottonLOGIC program.

Recent questionnaires have revealed that information is gathered from a number of sources. The Technology Resource Centre is helping provide research-based material to growers and industry as a whole in a number of convenient forms. They include paper based as well as electronic versions of documents.

In order to enhance the utilisation of resources the TRC has produced a searchable CD (the CottonPAKS CD) that allows users to search all the paks concurrently for key words of interest. The CD has the advantage of being fast compared to downloading the same documents via the World Wide Web. The CD is also relatively cheap to produce compared to paper manuals. Response to the concept has been positive following its release at the Australian Cotton Trade Show in May 2003.

The COTTONpaks CD.

Material produced by the TRC for distribution to industry

Product Name	Authors	Product Description
IRMS hot areas Central Queensland 2002-2003	Gunning, Herron, Tucker,Pyke, Wilson	TIMS CRC CRDC AIRAC Document layed out for web and used for pocket cards
Sowing decisions with reduced water supply	Compiled by Steve Milroy, Graham Harris Dave Larsen	Cotton CRC Information sheet
IRMS Macintyre Trial area		Special IRMS Shet For Macintyre Trial Area
Special standard check sheets for Macintyre IRMS Trial		Check sheet book for visual sampling
Special Beat check sheets for Macintyre IRMS Trial		Check sheet book for beat sheet sampling
IPM guidelines Support Document 1 "impact of insecticids and miticides on Predators in cotton October "	Lewis Wilson, Robert Mensah, Martin Dillon, Mark Wade	Support document update for IPM guidelines for web and print
Silverfeaf Whitefly in Australian Cotton	Kelly, Wilson, Parlato	CRC Research Review number 12
Management Of Silverleaf Whitefly in Australian Cotton November 2002	Kelly,Wilson,Parlato	CRC Research Review number 13
Hot areas Insecticidal Management for Silverleaf Whitefly for 2002-03 season	Kelly, Wilson, De Barro, Gunning, Franzmann	Australian Cotton CRC Information Bulletin Version 1 Current 10th December 2002. Web version
Warm areas Insecticidal Management for Silverleaf Whitefly for 2002-03 season	Kelly, Wilson, De Barro, Gunning, Franzmann	Australian Cotton CRC Information Bulletin Version 1 Current 10th Dcember 2002. web version
CottonPaks CD V1.0	Authors See Individual Paks – Compilation by David Larsen	CD Compendium of all COTTONpaks : SPRAYpak, Nutripak, SOILpak, WEEDpak, ENTOpak, IDM Guidelines, Cotton Production during Drought, Australian Dryland Prod'n guide.

PROJECT NUMBER: **4.3.01 AC**

PROJECT TITLE: **Developing innovative computer based technologies for effective delivery of information and cotton management decision support**

STAFF:

Dr Michael Bange, CSIRO Plant Industry, Narrabri, NSW
Stewart Whiteside, CSIRO Plant Industry, Narrabri, NSW
Darren Linsley, CSIRO Plant Industry, Narrabri, NSW
Sandra Deutscher, CSIRO Plant Industry, Narrabri, NSW
Scott Johnston, CSIRO Plant Industry, Narrabri, NSW
David Johnston, CSIRO Plant Industry, Narrabri, NSW
Dirk Richards, CSIRO Plant Industry, Narrabri, NSW
David Larsen, NSW Agriculture, Narrabri, NSW.

AIMS & MILESTONES:

- Extend the availability of computerised decision support systems, including mathematical models of cotton pests and crop production, industry databases, and extension material to all members of the cotton industry.
- Develop portable decision support tools for use in cotton crop management decisions.
- Maintain and develop innovative web-based technologies delivered via the Australian Cotton CRC's web site.

(i) Develop a replanting guide accessed via the web.
(ii) The development of a facility on the web site to provide dates of Helicoverpa diapause induction for each region

using real weather data.
(iii) Explore opportunities and implement where possible the use of multimedia for training and dissemination of information.
(iv) Monitor acceptance of web-based information and review objectives and achievements in the light of changing technology and needs of the industry and the Cotton CRC.
(v) Produce a final report.

OVERVIEW & OUTCOMES:

This project forms part of the overall achievement of the 'Cotton Management Support Systems' team based at Narrabri. In the past year we have been able to complete or attain:

- A handheld version of CottonLOGIC that will run on the Palm OS ® operating system for in field electronic data collection and decision-making was formally released at the Australian Cotton Conference. We consider this a world first for this technology.
- A prototype whole farm and field water accounting package and water use efficiency calculator. The water use efficiency officers in Queensland and New South Wales are presently testing this. To be included in CottonLOGIC.
- Development of a Prototype version of HydroLOGIC (Irrigation scheduling and management). was completed for preliminary testing this past summer. Preliminary results of field assessment show that HydroLOGIC can be used to maintain yields and improve water use efficiency.
- Resources to work with SILO to improve Cotton Industry's access to weather data through the Internet and CottonLOGIC software.
- Two additional tools for the CottonLOGIC handheld system: GPS capability and whitefly data entry.
- Facilitating the development of the updated Pest IPM guidelines.
- Completely redeveloped database driven website. This has increased the efficiency managing information on the web page.
- Two new prototype web driven tools for early season crop management have been developed, NutriLOGIC for nitrogen fertiliser management and Early Season Diagnosis (ESD) tool for with monitoring the development of crops. Both these tools are linked to the SILO day degree calculator.
- New software to more effectively monitor web usage has been identified and is currently being evaluated.

A new project that addresses current and future initiatives of information technology to assist cotton research dissemination has been funded to build on the initiatives started as part of this project.

Darren Linsley, Dr Michael Bange and Stewart Whiteside accepting the Asia Pacific Award:- Information and Technology award for Innovation in Natural Resource Management.

Scientific Exchanges

SCIENTIFIC EXCHANGE: **4.1.00 SX09**

Dr Michael Bange, CSIRO Plant Industry. To attend the Integrated Biological Systems Conference in Texas USA as Keynote Speaker

Dr Bange was a keynote speaker at this conference to present in the session titled 'Building and maintaining the bridge: From research to technology transfer'. His presentation covered the history of computerised decision support from SIRATAC to CottonLOGIC and reported on the issues that currently face developers of decision support.

The conference was a superb opportunity to advertise the knowledge gained in the Australian cotton industry in the development and use of computerised decision support systems. Dr Banges attendance provided a unique and focused opportunity to seek opportunities for future development of decision support systems and served to enhance his knowledge in this area. As a result of the visit, Dr Bange was asked to consider a sabbatical at Texas A &M University. Opportunities for future collaboration were also identified:

- Development of web-based decision support tools (specifically the work of Carlos Fernandez of Texas A&M).
- The use of a simple PSII leaf function meter to assess the performance of crop growth.
- The implementation of a participatory research approach across the Texas A&M system for delivery of research.

Dr Michael Bange making his presentation to the Integrated Biological System Conference.

SCIENTIFIC EXCHANGE: **4.1.00 SX10**

Dr Alice del Socorro (UNE) to attend the 19th Annual Conference of the International Society of Chemical Ecology, Hamburg, Germany, August 2002.

Dr Del Socorro presented a paper on "Bioassay methods for plant volatiles as attractants for Helicoverpa moths" at the ISCE conference where over 300 chemical ecologists were in attendance. The paper was well received, with positive feedback. The conference provided a good opportunity to meet and discuss related semiochemical work with overseas researchers. A positive outcome from these discussions is a proposal for collaborative work on "Olfaction in Heliothine moths" with the group of Dr. Hanna Mustaparta of the Nueroscience Unit, Norwegian University of Science and Technology. They will assist us in identifying plant volatiles that are detected by single receptor neurons in the antennae of *Helicoverpa* moths. Facilities for this type of research are not available in Australia.

Following the ISCE, Dr Del Socorro visited two Swiss universities. These were the Department of Applied Entomology, Institute of Plant Sciences, ETH-Swiss Federal Institute of Technology in Zurich, and the Laboratory of Animal Ecology and Entomology, Institute of Zoology, University of Neuchâtel, Neuchâtel.

In Zurich, a seminar on "Plant-based attractants for Helicoverpa moths" was presented to the entomology group at the Institute of Plant Sciences. Meetings and discussions about their current research on plant volatiles as insect attractants were held with Prof. Silvia Dorn, four team leaders in her group and post-graduate students. At the University of Neuchâtel, similar meetings and discussions were held with the research leader, Dr. Ted Turlings Jr, and his post-graduate students who are doing research on the chemical ecology of tritrophic interactions. These discussions were relevant to our own research on plant-based moth attractants, and also provided insights into other possible avenues of semiochemical research based on plant volatiles for Helicoverpa and other insect pests of cotton in Australia.

Dr Alice del Socorro centre at the conference.

SCIENTIFIC EXCHANGE: **4.1.00 SX11**

Mr Stephen Yeates to Travel to the USA to contact researchers and others with expertise relevant northern Australian Issues.

The study tour, conducted by Stephen Yeates from CSIRO Plant Industry, who is Northern Research Coordinator for the Cotton Cooperative Research Centre, covered a wide spectrum of research and extension activities including visits to the Universities of California, Arizona and Georgia, and Texas A&M University.

The aim was to investigate farming systems relevant to tropical Australia, for cotton grown in hot arid climates. The opportunity to examine cotton farming partnerships involving native Americans, to compare the potential for similar relationships with indigenous people in northern Australia was also conducted.

Several important challenges were highlighted including the effects of supra-optimal temperatures (climate risk assessment), rotations, cover crops, nutritional issues, managing nematodes, and controlling sucking pest, which appear more prominent in transgenic Bt crops, which will form the basis of any commercial cotton development in the north.

A highlight of the tour was the light soil overhead/drip irrigation farming systems of south Georgia, which were very similar to potential cotton farming systems for Katherine and Broome. The Georgia system showed the benefits of a peanut rotation, a cover crop and conservation tillage in light textured soils. Trials are planned to evaluate similar systems in northern Australia.

Stephen Yeates at the start of his study tour.

SCIENTIFIC EXCHANGE: **4.1.00 SX12**

Mr Dirk Richards, CSIRO Plant Industry, Narrabri to attend International Congress on Irrigation and Drainage, Montreal, Canada, July 2002.

This scientific exchange funded travel to the international congress and to visit cotton researchers and extension staff in the San Joaquin valley, California. This scientific exchange was aimed to broaden knowledge of cotton water management, which will assist the development and application of the OZCOT and HydroLOGIC tools, and to remain up-to-date with current research in the area of DSS, irrigation management and on-farm application adoption techniques.

The following topics were discussed during this travel and represent opportunities in research and extension in the Australian cotton industry; DSS and Precision Ag; IPM; Irrigation Advisory Services; The SWB irrigation model and educational package from the University of Pretoria; sociological studies on what is needed to convince water managers to measure and control their precious resource.

Three key recommendations resulting from this travel were; expansion of GIS mapping being conducted by Emerald growers and micro-satellite work in the southern valleys could assist greatly with IPM within the industry; aspects of the SWB model could be incorporated within HydroLOGIC and some of the reporting options may assist in interpretation by users; and there is a strong need to provide irrigation and other water related information in one place, such as in WaterPAK. All research agencies need to be involved with the development of this package, and we need to determine how the different software packages fit together.

Dirk Richards visited the Westside Research and Extension Centre, Fresno to discuss research trials in California. Pictured is the labour intensive irrigation with moveable aluminium tubing.

Summer Scholarships

REPORT NUMBER: **4.1.06 SS05**

REPORT TITLE: **Compensation from boll damage by mirids: an emergent threat to INGARD cotton**

STAFF:
Sara Winston-Smith, University of Sydney.
Dr Tom Lei, CSIRO Plant Industry, Narrabri NSW
Dr Lewis Wilson, CSIRO Plant Industry, Narrabri NSW.

Various field and cage experiments were carried out to explore new methodologies to address the issue of mirid damage in transgenic cotton crops. A field trial simulated boll damage by low, medium and high mirid infestations at 3 time periods during the fruiting stage of cotton. Artificial damage was applied by injecting pectinase enzymes into cotton bolls. Pectinases are constituents of the digestive enzymes in the mirid saliva injected into plant tissue during feeding. Three cotton cultivars were tested in this manner: Sicala V3i and Siokra V16i, and Sicot 71. The three levels of boll damage were: 5 (low), 20 (moderate) and 50 (high) bolls per metre. Each artificially damaged boll received 1.0 µl pectinase enzyme solution injected into a single lock per boll. Early damage took place 2 weeks after first flower, mid- and late damage treatments were imposed 3 and 6 weeks following the early damage. We are currently analysing the yield outcomes of this trial. At the completion of the data analysis, we will assess the relative degree of yield recovery from the various rates and timing of damage and begin to define the threshold of cotton to mirid damage.

Sara conducted a second set of experiments examining the effect of mirid damage to large squares. It is known that large squares fed upon by green mirids are not shed. Instead, they develop into flowers with damaged pollen sacs which lead to deformed bolls with a "parrot beak" appearance. The effect of this type of mirid damage is quite different from that resulting from direct boll feeding (i.e. no wounds on the boll wall and no discoloration of lint) and warrants investigation. We hypothesised that feeding (and the effect of digestive enzymes in the mirid saliva) on large squares degrades either the pistil column or the pollen sacs resulting in incomplete fertilisation of seed in discrete locules. This leads to the development of parrot beaked bolls as normal locules grow around the unfertilised empty locule. Experiments included simulating mirid damage to large squares by either piercing them with a needle or injecting 1 ml of pectinase into them, and caging late instar and adult green mirids with large squares. Damaged squares were tagged and assessed for pollen damage and boll deformation. The outcome of these experiments will allow us to develop appropriate experimental procedures to simulate mirid damage to large squares in future research.

The above photo's show the progressive damage that mirids cause to developing cotton bolls - called parrots peak.

PROJECT NUMBER: **4.1.06 SS08**

PROJECT TITLE: **Evaluating wet season cover crops as potential nurseries for dry season insects in the Ord River Irrigation Area.**

STAFF:
Tanya Gordon, University of Western Australia, Perth, WA
Dr Amanda Annells, NTDBIRD, Kununurra, NT.

Traditional farming practice in the Ord River Irrigation Area is to destroy stubble and cultivate fields, leaving them with a bare fallow over the tropical summer. Heavy rain events during the wet season have potential to cause severe erosion. In 2000 the Ord Land and Water Plan, formulated by growers and community groups, identified that "... farming practices must be designed to reduce erosion during both the cropping season and wet season by – (1). Growing cover crops to reduce erosion during the high intensity rainfall events leading up to the wet season…"

One advantage of maintaining clean fallow fields over the summer is that it minimises the availability of hosts for three key cotton pests, *Helicoverpa* spp., *Aphis gossypii*, and *Creontiades* spp. and populations are reduced to very low levels over the wet season. There is concern that if the incorrect cover crop species are chosen, large populations of these insect pests could develop over the wet season, and jeopardise commercial crops early during the following dry

season. This would increase the need for insecticide and possibly lead to a breakdown in integrated pest management.

This project evaluated the potential of six species of cover crops (soybean, pigeon pea, lablab, forage sorghum, Japanese millet and dwarf pear millet) to support the insect pests. These crops plus a weedy fallow were planted in December as three replicated blocks. Sampling for insects commenced in early January 2003 and was carried out over a five-week period.

Highest numbers of pests were associated with legume cover crops (Lablab, soyabean, pigeon pea) rather than grass cover crops. Negligible numbers of *Helicoverpa* and aphids were found over the period of study while a small number of mirids were observed. The predominant pests encountered were jassids, smaller numbers of lepidopterans, mirids and other hemipterans (Rutherglen bugs, apple dimpling bugs and cotton stainer bugs).

Predominant predators were beetles, ants, preying mantids and spiders. Damsel bugs, predatory shield bugs, big-eyed bugs, ladybirds and hover flies were also present but less common. More predators were found on the lablab than on other types of cover crops but this varied from week to week. Parasitic wasps were also more abundant on lablab than on other types of cover crops.

The greater number of insect pests found on the legumes may indicate that these types of cover crops could be potential nurseries for dry season pests in the Ord. The low number of heliothis and aphids found in the 2002-2003 wet season could be due to the abnormally hot dry summer and further investigation is probably needed to determine whether cover crop species could act as nurseries for these pests.

Tanya Gordon the Summer Scholarship student at Kununurra giving a seminar on her preliminary findings.

PROJECT NUMBER: **4.1.06.S099**

PROJECT TITLE: **Deep Drainage Maps for the Border Rivers.**

STAFF:
Claire Glendenning, The University of Sydney.
Dr Willem Vervoort, The University of Sydney.
Bronwyn Fisher, Border Rivers Catchment Coordinator, Goondiwindi QLD.

This summer scholarship allowed Ms Glendenning to work in Goondiwindi, Queensland, in association with the Border Rivers Catchment Management Authority (BRCMA) under supervision of the catchment coordinator Ms Bronwyn Fisher. The purpose was to develop a land use map as the basis for development of a deep drainage risk map for part of the Macintyre River Valley, west of Goondiwindi towards Toobeah. Both NSW and Queensland sides of the valley are encompassed in the study.

In order to create a deep drainage risk map, a landuse map of the area was developed, since landuse will determine whether the input is rainfall or irrigation. Landuse was determined from spectral signatures on a Landsat satellite image, followed by extensive groundtruthing. Arcview was used to digitized a landuse map for the area.

The development of a deep drainage map is proceeding as her Honours project. Using the Cotton CRC soils database sampled soil profiles have been identified in the area. Soil profile data will be transformed to hydraulic properties using pedotransfer functions in SINFERS. These will subsequently be used to simulate deep drainage in a dry and a wet year using a soil and water transport model (SWAP). Using a cut-off value for deep drainage, Ms Glendenning will then produce a deep drainage risk map, indicating the probability of deep drainage in the area.

PROJECT NUMBER: **4.1.06 SS11**

PROJECT TITLE: **Summer Scholarship - Susceptibility of native Gossypium spp. to cotton pathogens**

STAFF
Miranda Lei, The University of Sydney, NSW.
Dr David Nehl, NSW Agriculture, Narrabri, NSW.

AIMS & MILESTONES:
There is substantial overlap between commercial cotton production areas and the distribution of native Australian species of cotton and other species in the Malvaceae. The aim of this project was to investigate the potential for pathogens of cotton to infect and multiply on Australian species of *Gossypium* and selected weeds from the Malvaceae. *Bacterial blight*. Symptoms of bacterial blight, caused by *Xanthomonas axonopodis* var. *malvacearum* (Race 18), were

observed on artificially inoculated leaves of *Gossypium sturtianum* var. *nandewarense*, G. *bickii* and G. *australe*, and to a lesser extent on *G. sturtianum* (response indices on a scale of 0-5 were 1.7, 1.7, 1.2 and 0.7 respectively). These symptoms, however were much less severe than on susceptible cotton varieties Acala 44 and Pima S7 (response indices of 2.4 and 3.5 respectively). Lesions developed more slowly on the upper side of leaves than on the lower side of leaves. Lesions on *G. sturtianum nandewarense* were larger than on *G. sturtianum*. Among the malvaceous weeds, broad-leaf bladder ketmia (*Hibiscus trionum* var. *vesicarius*) and velvetleaf (*Abutilon theophrasti*) were mildly susceptible (response indices of 0.9 and 0.3 respectively), whereas anoda weed (*Anoda cristata*), (*Hibiscus panduriformis*), narrow-leaf bladder ketmia (*Hibiscus trionum* var. *trionum*) and spiked malvastrum (*Malvastrum americanum*) were not susceptible.

Black root rot. The severity of black root rot, caused by *Thielaviopsis basicola*, on tap roots (disease index on a 0-10 scale) was greater on *G. australe*, *G. sturtianum* and *G. sturtianum nandewarense* than on the commercial cotton variety Siokra 1-4 (disease indices of 5.3, 4.0. 4.0 and 3.6 respectively). Reproduction of *T. basicola* in the rhizosphere was 300 times greater on *G. sturtianum nandewarense* than on *G. sturtianum*, although their disease index was equal. *G. thurberi* (a non-Australian wild cotton) was highly resistant to black root rot.

Mycorrhizal colonisation. All species examined were colonised by arbuscular mycorrhizal fungi when grown in potted soil that did not contain *T. basicola*.

CONCLUSIONS:

Native cottons appear to have a low level of susceptibility to bacterial blight but may provide a harbour for the pathogen in the field. The native cottons examined were very susceptible to black root rot and are unlikely to be a source of resistance genes while *G. thurberi* may be a potential source. Populations of native cotton should be included in any future biosecurity plan for the cotton industry.

PROJECT NUMBER: **4.1.06 SS10**

PROJECT TITLE: **Viability of insect-borne cotton and canola pollen**

STAFF:

Jessica Richards, The University of New England.
Associate Professor Peter Gregg, University of Armidale.
Dr John Stanley, University of Armidale, NSW
Dr Alice Del Socorro, University of New England, NSW.

AIMS & MILESTONES:

The aim of this project was to determine the viability of pollen of cotton and canola carried by insects, especially *Helicoverpa* moths

The possibility of gene introgression into nearby conventional crops and weedy relatives has been a concern with transgenic crops such as canola, and to a lesser extent with cotton. Insect vectors can increase the distance travelled by pollen, and this has been studied mostly with honey bees. Noctuid moths such as *Helicoverpa* spp. are potential vectors of pollen over much larger distances than honey bees, though the amount of pollen they carry might be less. However, there is little information on whether the pollen remains viable over the time required for long distance movement by moths. The aim of this project was to investigate how long pollen from canola and cotton remained viable on the proboscis of *Helicoverpa* moths.

Cotton pollen viability was assessed by an *in vivo* pollen tube growth method. On glass slides at 25^{o}C and high humidity, cotton pollen remained viable for 16 hours, but there was a significant decline by 32 hours. There were no significant differences in this pattern between five cotton varieties, and there were no significant differences between Ingard® and conventional pollen in the one variety (Siokra V16) where this comparison was made. When cotton pollen was placed on the proboscis of live *Helicoverpa armigera* moths under the same temperature and humidity conditions, almost all the viability was lost within 8 hours. Addition to the germination medium of a homogenate prepared from moth proboscis did not reduce the viability of the pollen, suggesting that the mechanism depended on the presence of a live moth.

Similar results were obtained with canola pollen, the viability of which was assessed using a staining method. Moths could retain many more grains of canola pollen on their proboscis than cotton pollen, because of its smaller size and sticky nature. However, while on glass slides approximately 80% of pollen grains remained viable for 32 hours, on moth probosces, viability was reduced to about 10% within 8 hours.

These results suggest that the potential of *Helicoverpa* spp. (and possibly other moths) to faciliate pollen flow from GM crops may be less than could be expected, because the viability of the pollen is rapidly reduced by transport on the moth.

PROJECT NUMBER: **4.1.06 SS012**

PROJECT TITLE: **Comparison of established sampling methods with the new beat sheet technique for measurement of pest and predator abundance in cotton**

STAFF:

Carla McKinnon, University of Western Sydney, Hawksbury.
Martin Dillon, CSIRO Entomology, Narrabri, NSW.
Sandra Deutscher, CSIRO Plant Industry, Narrabri, NSW
Dr Sarah Mansfield, CSIRO Entomologt, Narrabri, NSW.
Trudy Staines, CSIRO Entomology, Narrabri, NSW.

AIMS & MILESTONES:

(a) Calibrate beat sheet sampling results relative to visual and d-vac for the key beneficial and pest arthropods in cotton crops.
(b) Quantify the degree of observer bias for arthropod counts from beat sheet and visual samples.
(c) Compare predator-prey ratios derived from visual and beat sheet samples in cotton.

OVERVIEW & OUTCOMES:

This summer scholarship project compared the efficiency of the beat sheet sampling method against established methods of visual checking and d-vac suction sampling. Our results clearly showed that beat sheets provide superior estimates of the densities of predatory beetles, bugs, lacewings, ants and spiders present in cotton. Beat sheets are also superior for green mirid nymphs and adults. On average, beat sheets detect twice the number of predators and green mirids than visual checks. However, our results showed that visual checking is best for all stages of Helicoverpa eggs and larvae, apple dimpling bugs, thrips, aphids, mites and whitefly. With the exception of small wasps, d-vac sampling was the least effective method of counting insects and spiders in cotton. A novel and effective method of obtaining absolute counts of insects present in a metre area of cotton was invented during the project: the “pounce-net”.

Beat sheet sampling was the fastest sampling method, taking between 3 and 5 minutes per metre. Suction sampling with d-vacs took a similar amount of time to the beat sheets, but involved collecting samples and processing them in a two-step procedure. The time taken to complete visual samples varied depending on the volume and complexity of the crop canopy. Visual sampling took 6 minutes per metre at the start of the season when plants were small, however sampling time increased as the crop developed, peaking at an average of 23 minutes per metre when plants had 20 or more mainstem nodes.

An experiment to quantify the relative degree of observer bias showed that for visual sampling there were statistically significant differences between observers in the numbers of predatory insects counted. In contrast, no significant differences between observers were detected for beat sheet sampling.

With respect to the predator to pest ratio outlined in the IPM Guidelines for Australian Cotton, counts from beat sheet samples need to be adjusted to reflect their increased efficiency in finding predatory insects and spiders. Our results suggest that for crops with more than 9 mainstem nodes, simply dividing beat sheet counts by 2 provides a reliable approximation of the numbers of predators that would have been found by visual counts. Once the beat sheet predator count has been divided by two, the result could be used for calculating the predator to pest ratio.

Carla McKinnon completing visual counts of key beneficial and pest arthropods in cotton.

Program Five Overview
Cotton Textile Research

Program Five Leader Dr Geoff Naylor CSIRO Textile & Fibre Technology.

In broad terms, Program Five, the relatively small post-harvest research program, is designed to enhance the commercial potential of Australian cotton in its key markets. The program utilises the fibre metrology and processing expertise of the Cotton Textile Research Unit, at CSIRO Textile and Fibre Technology in Geelong in conjunction with the broader range of research skills within the CRC to focus on this objective.

The program has had a particularly successful 12 months. The specific objectives of the two major projects within the program have been met and exceeded and the future for these projects looks very exciting.

Aims

The aims of Program Five are:

- To develop dyeing and bleaching technologies to support new products in cotton and cotton/wool blends.
- To reduce the environmental impact of cotton dyeing, bleaching and finishing.
- To improve the quality of processed cotton by identifying the fibre characteristics best suited to the efficient processing of Australian cotton, and to provide appropriate feedback to the producer.
- To enhance the ability of Australian cotton to compete, on the basis of costs and product versatility, with synthetic fibres.

Highlights and Achievements Against Milestones

1. The project examining the quality of Australian cotton from the mill's perspective is now well advanced. Mr Rene van der Sluijs has joined the team. His extensive industrial and scientific knowledge and experience as a Textile Technologist specialising in high quality cotton spinning is a major human resource asset to the project. The project team have travelled to Japan, South Korea and Thailand visiting and interviewing textile companies. Over 25 different companies representing 63 mills have been surveyed (This includes the Australian spinning industry.) As well as establishing an extensive data base of subjective data on the perceived quality of Australian cotton from these visits, 70% of the mills are supplying regular samples for extensive objective measurements. Planned travel and further linkages with the Indonesian industry were unfortunately postponed and are currently on hold due to the travel restrictions.

2. In a second aspect to the 'Quality of Australian Cotton' project, during the 2003 harvest season, a 'best practice' processing trial has been initiated. A range of different controlled custom ginned lots have been produced and these are in the pipeline for spinning at the CSIRO mill and a commercial mill in Thailand to demonstrate the benefits and full potential of Australian cotton to the processor.
3. A new technology has been developed for bleaching cellulose material including cotton. A provisional patent for this technology has been lodged and trials are underway to establish the technical and commercial potential of this technology. One exciting potential application of this technology is to the paper industry and this avenue is being explored in conjunction with CSIRO Forestry and Forest Products personnel.
4. A new project initiative was established to explore the unexpected finding that some irregularities in dyeing, a nagging problem for the textile industry, might be linked to unusual cotton wax compositions. Preliminary work yielded interesting results. Unfortunately, due to the current financial constraints, the project has been shelved for the moment.

Linkages

- Linkages continue with The Australian Cotton Shippers Association (ACSA). Indeed at ACSA's invitation Dr Stuart Gordon participated in a ACSA's recent trade exploration trip to China as the post harvest technical expert.
- Linkages with textile processing mills in Japan, South Korea, Thailand and Indonesia, the local spinning mill Associations, Austrade offices, the local textile machinery representatives as well as individual mills continue to strengthen.
- In the area of cellulose bleaching, a collaborative working relationship has been established with the paper pulp bleaching group at CSIRO Forestry and Forest Products at Clayton, Melbourne.

Project Summaries

PROJECT NUMBER: **5.1.01 AC (and 5.1.00 AC)**

PROJECT TITLE: **Technical Potential of New Bleaching Technologies**

STAFF:
Dr David Evans, CSIRO TFT, Geelong VIC.
Dr Jackie Cai, CSIRO TFT, Geelong, VIC
Jill McDonnell, CSIRO TFT, Geelong, VIC

AIMS & MILESTONES:

- To lodge a provisional patent for the IP generated from the previous project.
- To undertake further R&D during the period of the provisional patent to ascertain the commercial and full technical potential of the new bleaching technology and submit a report to the Cotton CRC.

OVERVIEW & OUTCOMES:

In the first stage of the project, extensive laboratory work was conducted to evaluate potentially effective chemicals and verify application conditions. Based on the results obtained, a provisional patent specification was prepared. By March 25, 2003, a provisional patent entitled "Methods for Bleaching Cellulosic Materials" was officially filed. The provisional patent covers potential applications of the invention in the bleaching of cotton, man-made cellulosic textiles and paper pulps, although to date the majority of laboratory work was confined to cotton textile materials. Some preliminary work has been conducted on other cellulosic fibres including wood fibres for paper pulps.

Following the filing of the provisional patent, we have initiated contact with relevant external organisations to explore the technical scope and commercial potential of the invention. Bleaching of paper pulp is an important potential application. Commencing in April, 2003, we have conducted preliminary pulp bleaching trials in collaboration with CSIRO Division of Forestry and Forest Products (FFP). FFP have also provided general information on industry procedures and on potential applications of the technology within the pulp and paper industry.

In addition, we have continued to evaluate other potential chemicals to refine the patent claims, and also identify more cost-effective alternatives. This will enhance the coverage of the invention and strengthen the full patent application.

To date, we have demonstrated the effectiveness of the new technology on thermomechanical pulp on a laboratory scale, while evaluations on other kinds of pulps are currently being undertaken. We have also modified the method which gives further improvement in the pulp bleaching effectiveness.

Further industrial contacts and collaboration with textile and paper manufacturers and chemical companies are planned for the future.

Dr Jackie Cai completing chemical analysis of the product in the CSIRO Textile and Fibre Technology laboratory in Geelong Vic.

PROJECT TITLE: **5.2.02 AC**

PROJECT TITLE: **New Dyeing Processes for Cotton**

STAFF:
Dr David King, CSIRO TFT, Geelong, VIC
Geni Kozdra, CSIRO TFT, Geelong, VIC.

AIMS & MILESTONES:

- Develop Cold Pad batch dyeing method for fabrics blended from cotton and wool
- Carry out pilot scale and industrial trials of method
- Investigate the use of chitosan as dyeing assistant for 100% cotton to reduce salt usage

OVERVIEW & OUTCOMES:
During the first two years of this project a pad-batch dyeing method for Colana was developed. This was an important step in getting greater uptake of this unique blend yarn containing 70% Australian cotton. Industrial trials were carried out at Bonds in Sydney and a Hong Kong manufacturer who is an important customer of Rocklea.

There are a number of problems created by using large amounts of salt in cotton dyeing, including increased corrosion of machinery, reduced efficiency of dyeing and most importantly the problem of dealing with salt-containing effluent. The aim of the last 12 months of this project was to find an alternative to salt by pre-treating the cotton to give it a greater affinity for dyes. Preliminary studies showed that chitosan is widely effective in promoting greater uptake of cotton dyes, but there is an unwanted side effect in the deterioration of the wash-fastness of the dyed cotton.

The results at this stage show that there is some merit in this potential new dyeing process due to its simplicity, the environmentally benign nature of chitosan and the importance of the problem to the cotton processing industry however the technical problems are unsolved at this time. The final report for this project has been prepared and submitted.

PROJECT NUMBER: **5.2.03 AC**

PROJECT TITLE: **Quality Issues for Australian Cotton from the Mill Perspective**

STAFF:
Dr Stuart Gordon, CSIRO TFT, Geelong, VIC
Martin Prins, CSIRO TFT, Geelong, VIC
Rene van der Sluijs, CSIRO TFT, Geelong, VIC
Stephen Ash, CSIRO TFT, Geelong, VIC

AIMS & MILESTONES:
The aims of the project are to:

- Understand quality issues related to the use of Australian cotton from the spinners perspective.
- Identify fibre quality problems and other textile processing problems associated with Australian cotton.
- Prioritise and tackle these textile processing related R&D problems to improve the export potential of Australian cotton.

Complete mill survey and processing (ginning and spinning) trials.

Identify any significant processing issues for Australian cotton and devise suitable R&D activities.

OVERVIEW & OUTCOMES:
The increased exposure and success of Australia's cotton in Asia has increased focus on research and development beyond the farm gate and in particular on the quality of the fibre. Currently, quality is measured relative to competitive growths such as San Joaquin Valley cotton from California, long regarded as the premium Upland growth in the world export market. While comparisons with other growths are important it is equally important that the Australian industry becomes proactive in the specification of its product. If Australia is to maintain and grow quality end markets it will need to extend the description of its product beyond the current USDA classing model and define it more in terms of its customers needs. This means the Australian industry must create its own quality benchmarks and specify

properties more relevant to its customers.

The objective of this project is to survey overseas spinning mills and test samples gathered from these mills to accurately assess the needs and perceptions of our customers so that the Cotton Industry can work towards its own quality benchmarks. Upon completion the survey will indicate the specific strengths and problems of Australian cotton with respect to spinning ability, nep content, short fibre content and length uniformity, fineness and maturity, colour and trash, contamination including handling and biological contamination, wax content and dyeing ability. To date over 25 mills in Australia, Japan, South Korea and Thailand have been visited and surveyed. The combined spinning capacity of these mills is over 1 million ring spindles and more than 35,000 rotor positions. Together these mills bought 177, 500 tonnes (or 780,000 bales) of Australian cotton in 2001/02. Of the mills over 70% are regularly contributing cotton fibre samples for measurement as part of the survey. In addition spinning trials using best management practice custom ginned cotton are about to commence in an overseas spinning mill and at the CTFT mill in Geelong. The objective of these spinning trials is to reflect in commercial terms the value of best practice benchmarks with regards to ginning and spinning preparation.

Results from the survey and trials will provide true benchmarks of Australian cotton fibre quality. Moreover the project is generating procedures and associations for future benchmarking activities. From this information the Australian cotton industry will be able to determine more accurately its priorities with respect to marketing its strengths and improving quality through R&D and extension of R&D outcomes.

Dr Stuart Gordon.

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3.1.29 **Hulugalle, N.R., N'Kem, J.N. and Lobry de Bruyn, L.A.** (2002). Invertebrate populations and N cycling during the wheat phase of wheat-cotton rotations in a Vertosol. In "Future Soils: Managing Soil Resources to Ensure Access to Markets for Future Generations", Proc. National Conference of Australian Soil Science Society Inc., 2-6 December 2002, Perth, WA, pp. 225-226. (ASSSI, Perth, WA).

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4.2.02 **Harris, G.A, Hood, S., Okello-Okanya, J. and Wigginton, D. (**2002) "Irrigated peanut performance in Southern and Central Queensland during the 2001-02 Season", *National Peanut Update 2002*, 5th-6th September 2002, Kingaroy

4.2.04 **Christiansen, I. and Dalton, B**. (2002) Understanding IPM – Industry Attitudes, Practices and Education. 11th Australian Cotton Conference, 13th – 15th August 2002, Brisbane, Australia.

4.2.05 **Christiansen, I. and National Cotton Extension Network** (2002) Extension and Profitability – Implementation of Profitable and Sustainable Approaches. 11th Australian Cotton Conference, Australian Cotton Growers Research Association, August 2002, Brisbane.

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4.2.05 **McIntyre, G.T., Gibb, D., Shaw, A.J., Christiansen, I.A. and Pyke, B.A**., (2003). Extension in the Australian Cotton Industry, World Cotton Research Conference 3, 10th – 14th March, 2003, Capetown, South Africa.

4.2.07 **Hoque, Z., Dillon, M. and Farquharson, B**. (2002). 'Three seasons of IPM in an Areawide Management Group – a comparative analysis of field level profitability'. Proceedings, 11th Australian Cotton Conference, The Australian Cotton Growers' Research Association, Brisbane, Queensland, August 13 –15, pp. 749-755.

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4.3.01 **Deustcher, S.D., Bange, M.P., Johnston, S., Larsen, D., Linsley, D., and Whiteside, S**. (2002). Introducing CottonLOGIC for the Palm OS® handhelds. In Proc. 11th Aust. Cotton Conf. 13-15 August, Brisbane Aust. The Aust. Cotton Growers Research Organisation, pp. 831-835.

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3.2.12 **Rencken, I.C., Silberbauer, L ., Reid, N., Gregg, P**. (2003) In Press The importance of native vegetation to beneficial insects and its role in reducing insect pest damage in cotton World Cotton Research Conference-3, Cape Town, South Africa, 9-13 March 2003.

Roth, G.W. (2003) Monitoring the sustainability of cotton production systems, Proceedings of the 3rd World Cotton Conference, Capetown, South Africa, 9-13 March 2003.

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Book Chapters

3.1.11 **Odeh, I.O.A. and McBratney, A.B.** (2002) Newer application techniques– fuzzy sets. Chapter 1.8.2. *In:* Methods of Soil Analysis Part 4—Physical Methods. Soil Science Society of America Book Series: 5, Madison Wisconsin. pp 171-184.

3.1.30 **Mansfield, S**. (in press). Book review of "Insects and Pest Management in Australian Agriculture" for *Austral Ecology.*

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3.2.02 **Silberbauer, L. and Gregg, P**. (in press) Tracing short-term beneficial insect movement through insect-borne pollen. Proceedings of the First International Symposium on Biological Control of Arthropods, Hawaii, USA. January 2002.

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3.2.02 **Reid N., Silberbauer, L. and Thompson, D.** (2002) Cotton and the Environment – Ecosystem Services. 11th Australian Cotton Conference - Proceedings, Brisbane, August 2002

Theses

3.1.29 **Gleeson, J.E.** (2002). The effect of tillage on the soil furrow characteristics, crop growth and water use of cotton in an irrigated Vertisol. B. Sc. (Agric.) Thesis, University of Sydney, Sydney, NSW.

Smith, R (2002). Environmental Monitoring in the Australian Cotton Industry - Benchmarking the Pesticide Content and Quality of Irrigation Water Throughout the Dirranbandi District. University of New England Bachelor of Rural Science (Honours)

Annis Brown, E (2002). Economics of alternative irrigation systems. University of New England. Bachelor of Agricultural Economics.

Black, KT (2002) The effects of cotton defoliants on olive trees. University of New England, Bachelor of Rural Science.

Hicks, A. (2002). The effect of effluent irrigation and gypsum on the soil properties of a Vertisol and growth of cotton. B. Sc. (Agric.) Thesis, The University of Sydney, Sydney, NSW.

Roberts, P. (2002). The use of a minirhizotron to observe the effect on root growth caused by minimum and maximum tillage treatments. B. Sc. (Agric.) Thesis, The University of Sydney, Sydney, NSW.

Presentations, Public Relations & Communications

2.1.01 **Fitt, G.P.,** (2003), The World Cotton Research Conference 3rd . Dr. Fitt presented an invited paper and three posters at the meeting. March 2003, in Cape Town, South Africa.

2.1.01 **Fitt, G.P. (**2003), The CRC Association Conference, May 2003, Canberra, ACT.

2.2.03 **Del Socorro, A.P. and Gregg, P.C**. (2002). Bioassay methods for plant volatiles as attractants for *Helicoverpa* moths. International Society of Chemical Ecology 19th Annual Meeting, August 3-7, 2002. Hamburg, Germany.

2.2.03 **Britton, D., Del Socorro, A. O'Keefe, S., Dawson, B. and Gregg, P.** (2002). An electric grid trap for attractant testing, mark-recapture and autodissemination applications. International Society of Chemical Ecology 19th Annual Meeting, August 3-7, 2002. Hamburg, Germany.

2.2.04 **Weir, K.M**.(2002) Isolation and characterisation of enzymes capable of degrading the pesticide endosulfan. Australian Society for Microbiology Annual Conference, 2002, Melbourne.

2.2.12 **Gulino, L.M., Bentley, S., Kochman, J.K., O'Neill, W.T., Swan, L.J., George, E.L., Allen, S.J., Moore, N.Y., and Irwin, J.A.G.** (2003). A DNA diagnostic test for detection and identification of Australian strains of fusarium wilt of cotton. Poster presented at the 8th International Congress of Plant Pathology, 2-7 February, 2003, Christchurch, New Zealand.

3.1.03 **Bange, M.P**. (2003) 'Cotton Decision Support Systems and OZCOT Development'. Cotton Consultant Australia Annual Meeting, 12th June 2003, Narrabri.

3.1.07 **Roberts, G.N.** (2003). Factors influencing crop maturity in the Australian cotton industry. 3rd World Cotton Conference, March 10th-13th Cape Town, South Africa.

3.1.09 **Harvey, J.A. (**2003) Pathogenicity and Diversity of *Thielaviopsis basicola,* FUSCOM 2003, 25th-26th February, Toowoomba Australia.

3.1.11 **Odeh, I. O.A. Triantifalis, J. and McBratney, A.B**. (2003) Is soil quality declining under cotton production systems in eastern Australia? Oral presentation at the 3rd World Cotton Conference, March 10-14, 2003. Cape Town South Africa.

3.1.20 **Speirs, S.D., Cattle, S.R. & Hulugalle, N.R**. (2002) Characterising soil structural stability and form of sodic soil used for cotton production. Field to Fashion, 11th Australian Cotton Conference. 13th– 15th August 2002. Brisbane, Queensland, Australia (Poster presentation).

3.1.30 **Mansfield, S., Dillon, M. L. & Whitehouse, M. E. A.** (2002). Do beneficials pay their way? Poster, Annual Meeting of the Ecological Society of Australia, 2-6 December, Cairns, Qld.

4.2.02 **Hood, S.** (2002) Rural water use efficiency- Real water use efficiency and the opportunities. Proceedings 11th Australian Cotton Conference, Brisbane, Queensland Australia. pp 585-595.

4.2.02 **McIntyre, G.T. and Goyne, P.J.,** (2003). Water Use Efficiency Extension in the Queensland Cotton and Grains Industries – an industry partnership, World Cotton Research Conference 3, 9th – 13th March, 2003, Capetown, South Africa.

4.2.04 **Dalton, W., McIntyre, G.T., Gibb, D., Hickman, M. and Kauter, G**. (2003) 'Australian Cotton Cooperative Research Centre IPM Short Course – An Industry Learning Together', 3 rd World Research Cotton Conference, 10th – 14th March 2003 Capetown, South Africa.

4.2.07 **Dillon, M., Hoque, Z. and Farquharson, B**. (2003) The Beneficial Disruption Index: A tool for comparing insecticide regimes applied to crop fields. Presentation at the World Cotton Research Conference-3. 9-13 March 2003, Cape Town, South Africa.

3.1.12 **Yan, F**. (2002) 'Soil microbial diversity and black root rot suppression in cotton', and poster. The 11th Australian Cotton Conference, August 2002, Brisbane.

3.2.02 **Silberbauer, L.X., Reid, N. and Thompson, D.** (2002) Modelling pest management options in cotton within an ecosystem services framework. Oral presentation to the Ecological Society of Australia & Ecology Society of New Zealand combined conference, Cairns, December 2002.

3.2.02 **Rencken, I., Silberbauer, L.X., Reid, N. and Gregg, P**. (2002) Real Estate Hunters in the Namoi Valley in Northern NSW. Poster presentation to the Ecological Society of Australia & Ecology Society of New Zealand combined conference, Cairns, December 2002

3.2.07 **Downey, A.J. (2002) "**The Effects of Cotton Defoliants on Native Trees from North-West NSW – Field-Based Experiments, Cotton CRC Annual Science Review, August 2002 Toowoomba, QLD

3.2.12 **Rencken, I.C., Silberbauer, L., Reid, N. and Gregg, P**. (2003) The importance of native vegetation to beneficial insects and its role in reducing insect pest damage in cotton World Cotton Research Conference-3, Cape Town, South Africa, 9-13 March 2003

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Seminars, Workshops & Trade Shows

Roth, G., (2002) Managing research finances. One day presentation to Master Class of Research management to 20 International Scientists The Crawford Fund, Sydney, 6 December.

1.1.01 **Yeates, S.J**. (2002). An overview of northern research, Australian Cotton CRC Review, June, Toowoomba, Qld

Cotton CRC and CRDC hosted a two day Farming System workshop for growers and researchers at Narromine, December 2002 on Salinity, Sodicity and hard setting soils. The workshop was facilitated by I Christiansen, H Dugdale, G Roberts and G Roth.

1.1.01 **Yeates, S.J.** (2002). Overview of cotton research in northern Australia, Monsanto, August, St Louis, USA.

1.1.01 **Yeates, S.J**. (2002). NT cotton research and implications for the Roper catchment, Roper Land Care Group, August 2002, Mataranka, NT.

1.1.01 **Yeates, S.J**. (2002). Northern Australian Cotton CRC Review, November 2002, Darwin, NT

2.1.01 **Fitt, G.P. (**2002) The 1st Workshop of the "International Working Group on Genetically Modified Crops in IPM", Nov 2002 held in Nairobi, Kenya.

2.1.01 **Fitt, G.P.** (2003), The 2nd Workshop of the "International Working Group on Genetically Modified Crops in IPM" June 2003, held in Brasilia, Brazil.

2.1.01 **Fitt, G.P. (**2003), The 1st Charles Darwin Symposium to discuss development options for northern Australia, May 2003, held at the Northern Territory University, Darwin, NT

2.1.01 **Fitt, G.P. (**2003), An Area-wide management/ IPM meeting, June 2003 at QDPI, Toowoomba, Qld.

2.2.03 **Del Socorro, A.** (2002). *Plant-based attractants for Helicoverpa moths*. Seminar presented to the Dept. of Applied Entomology, Insitutute of Plant Sciences, ETH-Swiss Federal Institute of Technology, Zurich, Switzerland, August 2002.

2.2.03 **Gregg, P**. (2002). *Attract-and-kill with semiochemicals*. Cotton Consultants Australia Certified Workshop, Wee Waa, 12 September 2002.

2.2.04 **Sutherland, T.D**.(2002) Discovery and adaptation of enzymes for bioremediation technologies, CSIRO Biotechnology Conference, 2002, Noosa.

2.2.04 **Horne, I**. Evolving enzymes for a cleaner environment. Bio2 CSIRO Biotechnology Conference, Brisbane 2003.

2.2.12 **Kochman, J., Swan, L., O'Neill, W. and Allen, S**. (2003) presented reports on the non-molecular aspects of research related to this project. **Gulino, L. and George, E**. presented a report on the molecular diagnostics research. Project staff participated in the *Fusarium* Workshop (25-26 February, 2003) coordinated by the CRDC to review research results, identify gaps and establish collaborations amongst Australian cotton research groups.

3.1.03 **Richards, D. and Bange, M.P**. (2002) - Dryland crop potential, fibre quality and the OZCOT software at the CSD Summer Cropping Dryland meetings, 9/10th of September 2002, at Bellata, North Star and Dalby.

3.1.03 **Richards, D**. (2002) Outlining applications of the OZCOT model, response curves for first irrigation and water allocation for the current season, and other potential uses. NSW Agriculture Irrigation course, 21st Oct 2002, ACRI, Narrabri.

3.1.03 **Richards, D**. (2003) Outlining the HydroLOGIC trial at ACRI, key results to date, and the future potential of the HydroLOGIC software. Presentation to a group of Bourke cotton growers on the 30th January 2003, Bourke.

3.1.03 **Richards, D.** (2003), HydroLOGIC software, research results to date and other related irrigation research. Presentation at the Lower Namoi field day on the 20th Feb 2003, ACRI, Narrabri.

3.1.03 **Richards, D.and Hickman, M.** (2002), The physiology of water stress and OZCOT generated information on first irrigation and water allocation, and outlined management options for growers. Conducted a series of Limited Water workshops in response to the drought and limited water allocations for the 2002-03 season. . Meetings were held at Bourke (2nd July), Dalby (9th July), Gunnedah (19th Sept), Hillston (29th Oct), Moree (8th Nov), Trangie (11th Nov), and Narrabri (13th Nov).

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The story is also reproduced on CSIRO Entomology's website: http://www.ento.csiro.au

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Awards

2.1.01 **Fitt, G.P.** Mackerras Medal, Australian Entomological Society, 2002

2.1.01 **Fitt, G.P.** Adjunct Professor of Entomology, Faculty of Agriculture, Food & Natural Resources, University of Sydney, 2003

2.1.01 **Fitt, G.P.** Centenary Medal, Commonwealth of Australia, 2003

2.2.04 **Weir, K.M**. Becton Dickinson Award, Canberra Branch of the Australian Society for Microbiology. June 2002. Canberra.

2.2.04 **Weir, K.M.** Student Speaker Award, Rice CRC Student Symposium, February 2003, Yanco Agricultural Institute, Canberra.

4.2.02 **Rural Water Use Efficiency Initiative Cotton and Grains Adoption Program.** 2003 Queensland Primary Industries Environment Award. April 2003, Brisbane.

4.3.01 **CottonLOGIC** for Palm OS handhelds won the Natural Resource category of the Australian component of the Asia Pacific Information and Communication Technology Awards.

3.2.01 **Rose, M. (2002)** The Harvey W. Wiley Scholarship, 116th AOAC Annual Meeting, Los Angeles, CA, USA.

AFFA Science and Innovation Award for Young People, August 22, Canberra, Three cotton industry staff were successful in gaining AFFA awards valued at $8000 to support specific projects. These were: **Nicky Schick** (CRC Research Liaison Officer) – Cotton Industry Award - project on the types of incentives and institutional structures required for the industry to fully embrace natural resource management. **Andrew Davies** (CRC PhD student) – Western Australian Regional Awards – project examining biological control agents that could assist cotton expansion in northern regions. **Sven Delaney** (CRDC PhD Student) – South Australian Regional Award – project on cotton fibre development.

Visitors

Dr. Ravi, K.C. Ph.D Sr. Seminar "Resistance Management Needs for Bt Cotton in India" Scientist Monsanto Research Center Bangalore, 11th April, 2003, ACRI Conference Room, Wee Waa Rd, Narrabri.

Mark Sears. Seminar "Measuring Environmental Effects of Transgenic Corn, the Canadian Experience". 18th November 2002, ACRI Conference Room, Narrabri.

Kendle Wilkinson (CDI) Postdoctoral Fellow with the Centre for the Identification and Diagnostics of Insects and Weeds, School of Life Sciences at The University of Queensland gave a seminar on his project "Genetic Analysis of Heliothis in the Lower Namoi Valley", 7 November 2002, ACRI, Narrabri.

Dr Rob Lind Syngenta Program Manager Insecticide Discovery Jealott's Hill International Research Centre (UK) Seminar: Insecticide Discovery (Modern Techniques), 31st January 2003, Australian Cotton Research Institute - Narrabri

Dr. Peter Ellsworth, IPM specialist with Department of Entomology, University of Arizona. Seminar "Whiteflies in Arizona: An IPM Success Story" 19th December,2002, ACRI Conference Room, Narrabri.

Dr Rebecca Letcher Centre for Resource & Environmental Studies, ANU, 5th November, 2002.

Chinese delegation of farmers and Textiles representatives, 15th January, 2003

Jim Hannan visiting USA scientist, 28th January, 2003.

Charles Willcock AFFA - Industry Partnership Program, 18th February, 2003. Attended a meeting with Cotton CRC.

Pakistan Farming Group visit, 10th April, 2003.

Review of Riparian Guidelines, **Phil Price and Siwan Lovett**, 6th May, 2003.

Narrabri and Wee Waa High School teachers - Overview of Cotton Research, 22nd July, 2002

Glen Wilson Lead Scientist, Northern Murray-Darling Research Lab, and Mark Southwell Community Scientist. CRC Freshwater Ecology overview research program. 25th October, 2002.

Cotton CRC/ ACRI hosted a student group visit by Students from **Marsden High School**, on April 1, 2003, to discover something of the science underpinning cotton production. The afternoon covered IPM, GM cottons, Breeding and sustainability.

Public Relations

4.2.05 **Christiansen, I. (2003)** Extension Network, Cotton Tradeshow, 27-28 May, 2003, Moree.

4.2.06 **Christiansen, I. (2003)** Wincott Agronomy Field Day, 11 February,2003, Boggabri.

4.2.08 **van Dongen, P. (2003)** Crop of the Year Award, Macquarie Cotton Awards Dinner, April, 2003.

Fitt, G.P. Roth, G.W. Schick, N. Milroy, S. (2002) Cotton CRC had a display at the Brisbane Rivers Symposium, 4-5 September 2002, Brisbane Exhibition Centre.

Roth, G. Schick, N. gave a presentationto the Macquarie Catchment Board on CRC research, NSW 30th October 2002.

Fitt, G. Schick, N. Roth, G. gave a presentation to the Catchment Board Chairs and executive staff, Tamworth, NSW 24th October 2002.

Fitt, G. Schick, N. Roth, G. MacIntyre, G gave a presentation to the South East Queensland Catchment Management Committee, tara, QLD 11 November 2002.

Cotton CRC displays at the River Symposium, Brisbane (4-6 September, 2002), including our 'Good News Brochure' in the conference bags, several posters and two submitted talks. Moree Trade Show (May 2003),

Fitt, G.P., Roth, G. (CRDC), Triantifalis, J. (USYD) and Rose, M. (USYD Postgrad) gave presentations to a group of YSYD 4th years students to highlight career opportunities in science and research. PhD projects and research needs for industry were covered. Guy Roth gave a similar presentation to UNE students on October 25.

Fitt, G.P. October 29, 2002 – participation in Strategic Planning Meeting for CRC Tropical Plant Protection, Brisbane.

CSIRO and the Cotton CRC launched the hand-held version of CottonLOGIC (CottonLOGIC for the PalmOS) at the last Australian Cotton Conference, August, 2002 Brisbane. Dr. Mike Bange (CSIRO Plant Industry) who leads the development team, also nominated the new tool for the 2002 Asia Pacific Information-Communication-Telecommunication Awards in the category of tools for Natural Resource Management. Some 190 projects were submitted for judging. On November 2nd, 2002 at a function on the Gold Coast, CottonLOGIC for PalmOS was judged the WINNER of the Asia Pacific ICT Awards in the Natural Resource Management category. Mike Bange, Darren Linsley and Stewart Whiteside (all CSIRO Plant Industry and CRC) attended the award ceremony. · CottonLOGIC for the PalmOS and the team will now represent Australia in this category at the International ICT Awards to be held in Cairns next year

Cotton CRC had a display stand at the World Cotton Research Conference Capetown, March 2003, to highlight our research and extension activities and particularly to highlight potential educational opportunities aligned with the Cotton Production Course. A flyer on future short courses is being developed. Twenty two Australian researchers are being supported to attend.

Cotton CRC & CRDC met with Environment Australian and AFFA, 14 November, 2002, to discuss environmental research needs and the cotton industry.

Cotton CRC, CRDC and Freshwater Ecology CRC CEO Prof. Gary Jones met on 17th December, 2002, to discuss common arears of interest and potential future interactions.

Cotton CRC, CRDC & Cotton Australia met July 24, 2002, to discussed our involvement in natural resource management issues.

Fitt, G.P. attended the QLD Science in Parliament day (August 20, 2002) which involved presentations from Qld premier Beattie, Qld Chief Scientist Dr. Joe Baker and Australia's Chief Scientist, Dr Robin Batterham.

Fitt, G.P. attended the AFFA Science and Innovation Award for Young People, August 22, 2002, Canberra.

Fitt, G. P. made a presentation at the Chemcert Conference, September, 2002, Chemcert National Forum which has a theme of: Food and Fibre Safety: Managing the Risks while Maintaining the Farm. Gary participated in a forum session of the topic of "The Farmers Role in Natural Resource Management".

Fitt, G.P. attended the first Workshop of IOBC Global Working Group, Kenya on 25-30 November, 2002.

Reid, N.(UNE) and Gibb, D.(NSW Ag) represented the CRC in a workshop (March 10/11) to refine the Barwon investment plan. A comprehensive document was developed for the workshop outlining the Cotton CRC's research and extension capacities and detailing a range of projects which we believe deliver outcomes for the plan. Several of these have now been written into the investment plan.

Fitt, G.P. attended a meetings Brisbane on January 23 to discuss QDNR Sustainable Agriculture Initiative (SASI) and Emerald Catchment GIS project. Opportunity to highlight Cotton CRC capacity in relevant areas, particularly WUE Extension. Emerald project is a model for what could be done in other cotton catchments.

Fitt, G.P. attended a meeting with Col Creighton, LWA to discuss CRC proposals to National Program for Sustainable Agriculture. February 11, 2003.

Fitt, G.P. attended meeting with USYD, Professor David Goldny and Assoc. Professor Geoff Gurr, Orange February 28, 2003 to discuss potential joint research in integrated natural resource management.

Fitt, G.P. attended the FUSCOM Annual research review meeitng, February 25-26, 2003.

Fitt, G.P. attended the IOBC Global Working Group meeting, on GM Crops in IPM Systems, to review progress from the Kenyan Workshop and plans for the future. As a member of the project executive I presented the outcomes of the Resistance Management Section of the Guidelines Project.27-28 February, 2003, Bangkok.

Fitt, G.P. attended a meeting with Qld Catchment Groups; QMDC , Condamine Alliance and DPI Ag SIP planners to discuss capabilities of the Cotton CRC to deliver relevant outcomes for catchment plans. We hope for similar involvement in the planning process to that experienced in NSW. Two proposals have been submitted so far. And these have been further brokered by DPI. Toowoomba, March 28, 2003.

Fitt, G.P. invited to give the Occasional Address at the Graduation Ceremony for the Faculty of Agriculture, Food and Natural Resources at University of Sydney on April 11. I used the opportunity to discuss the city/country divide and the media's role in reinforcing this. I have also been advised that University of Sydney has conferred on me the position of Adjunct Professor in Entomology for a period.

Fitt, G.P. attended on April 12, 2003 Royal Easter Show, Sydney and spoke on the "Science of Cotton" in the Ag Learning Centre at the show. Hosted by Neil Inall, the session was an opportunity to discuss water use in cotton and the MDBC, GM crops and their role in cotton among other issues with a largely urban audience.

Roth, G. Schick, N. Fitt, G. Advancing Regional Careers Marsdow, Wee Waa and Narrabri High Schools April 2003.

Auditor's Report

MICHAEL A. CARRIGAN & Co.
A.B.N. 65 365 735 356
CHARTERED ACCOUNTANTS

PARTNERS:
Michael A. Carrigan B. Comm, FCA
S. Louise Gett B.F.A., CA
Calvin C. Skues B.Bus. CA
David A. Maxwell B.F.A. CA

AUDITORS REPORT TO THE CO-OPERATIVE RESEARCH CENTRES PROGRAM, DEPARTMENT OF EDUCATION, SCIENCE AND TRAINING REPRESENTING THE COMMONWELTH IN RESPECT OF AUSTRALIAN COTTON CO-OPERATIVE RESEARCH CENTRE

FINANCIAL INFORMATION FOR THE YEAR ENDED 30 JUNE 2003

Scope

We have audited the financial information of the Australian Cotton Co-operative Research Centre as set out in Tables 1 and 2 of the Annual Report (being the tables showing in-kind and cash contributions for each party to the CRC, and cash expenditure) for the year ended 30 June 2003. The parties to the Australian Cotton Co-operative Research Centre are responsible for the preparation and presentation of financial information. We have conducted an independent audit of the financial information in order to express an opinion on it to the parties to the Australian Cotton Co-operative Research Centre.

The financial information has been prepared for the parties to the Australian Cotton Co-operative Research Centre for the purposes of fulfilling their annual reporting under clause 14 (1) (f) of the Commonwealth Agreement and for distribution to the Cooperative Research Centres Program, Department of Education, Science and Training, representing the Commonwealth of Australia. We disclaim any assumption of responsibility for any reliance on this report or on the financial information to which it relates to any person other than those mentioned above, or for any purpose other than that for which it was prepared.

Our audit has been conducted in accordance with Australian Auditing Standards to provide reasonable assurance as to whether the financial information is free of material misstatement. Our procedures included examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial information, and the evaluation of accounting estimates. These procedures have been undertaken to form an opinion whether, in all respects, the financial information is presented fairly in accordance with the Australian accounting concepts and standards and requirements of the Commonwealth agreement in terms of Clauses 4 (Contributions), 5(1), 5(2), 5(3) (Application of the Grant and Contributions), 9(1), 9(5) (Intellectual Property) and 12(2) (Financial Provisions), so as to present a view of the sources of funding an the application of funding of the Australian Cotton Co-operative Research

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Centre and the application of which is consistent with our understanding of its financial activities during the year and its financial position.

While we have not performed any audit procedures upon the estimates for the next period and do not express any opinion thereon, we ascertained that they have been formally approved by the Governing Board as required under the Joint Venture Agreement.

The audit opinion expressed in this report has been formed on the above basis.

Audit opinion

1. The multipliers adopted by the Centre to value in-kind contributions other than salary costs have a sound and reasonable basis and each partner's component of the Researcher's Contributions for the year under report has been provided at least to the value for that year committed in the budget as specified in the Agreement. The total value of all Contributions for the year under report equalled or exceeded the amount of grant paid during the year (not including advances). (Clause 4)

2. The researcher has used the Grant and the Researcher's Contributions for the Activities of the Centre and in my professional opinion there appear to be no material reporting irregularities. (Clause 5(1))

3. The Researcher's allocations of the budgetary resources between Heads of Expenditure has not been lower or higher than the allocation in the budget by $100 000 or 20% (whichever is the greater amount) without prior approval by the Commonwealth. (Clause 5(2)) With the exception of:

    - salaries which were $2,577,000 over the original budgeted figure for the respective heads of expenditure.
    - other expenditure which were $1,222,000 over the original budgeted figure for the respective heads of expenditure.

4. Capital Items acquired from the Grant and Researcher's Contributions are vested as provided in the joint Venture Agreement. (Clause 5(3))

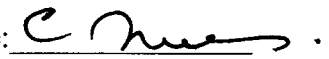
5. Intellectual Property in all Contract Material is vested as provided in the Joint Venture Agreement and no intellectual Property has been assigned or licensed without the prior approval of the Commonwealth. (Clause 9(1), 9(5)) (**or:** A statement signed by the Director/CEO or Board Chair, to the effect that Intellectual Property in all Contract Material is vested as provided in the joint Venture Agreement and no Intellectual Property has been assigned or licensed without the prior approval of the Commonwealth (Clause 9(1), 9(5)), has been seen by the Auditor.)

6. Proper accounting standards and controls have been exercised in respect of the Grant and Researcher's Contributions and income and expenditure in relation to the Activities of the Centre have been recorded separately from other transactions of the Researcher. (Clause 12(2))

Date: 18th November 2003

Firm: Michael A. Carrigan & Co.

Address: 1/155 Maitland Street
Narrabri NSW 2390

Signature: 

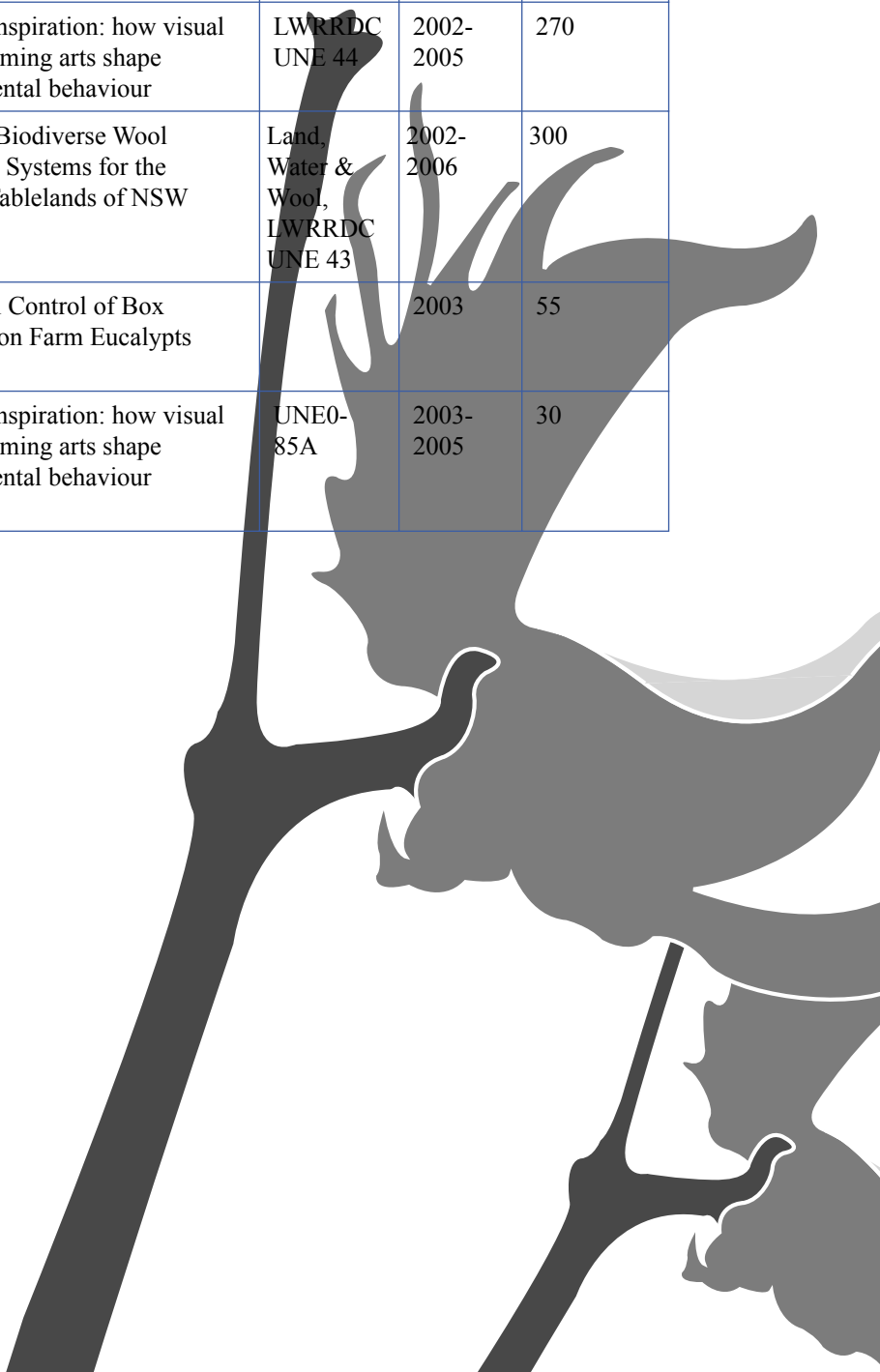
Partner: Calvin C Skues

Grants

Current Research Grants held by Key Cotton CRC researchers

RESEARCHER	ORGANISATION	TITLE	SCHEME	GRANT PERIOD	GRANT AMOUNT
Dr. Lewis Wilson	CSIRO Plant Industry	Incorporating aphids, insecticides and early season plant compensation in IPM	CRDC	3 yrs	525
Dr. Lewis Wilson	CSIRO Plant Industry	Identification and management of 'Bunchy Top' syndrome	CRDC	3 yrs	585
Dr. Lewis Wilson	CSIRO Plant Industry	Improving understanding of the ecology and management of cotton aphid.	CRDC	3 yrs	264
Dr Lewis Wilson/Dr Geoff Baker	CSIRO PI / CSIRO Entomology	Enhancing the impact of early season predation on helicoverpa spp.	CRDC	2001-2004	457
Dr. Michael Bange/ Rose Roche/ Stephen Milroy	CSIRO Plant Industry	Training in crop physiology – Physiological determinants of Ultra Narrow Row Cotton	CRDC	2001-2004	76
Assoc. Professor Alex McBratney	The University of Sydney	Variable-rate application on nitrogen: the determination of an empirical methodology for implementation.	Australian Research Council SPIRT	2001-2003	38
Assoc. Professor Alex McBratney	The University of Sydney	Development of an 'on-the-go' soil pH sensing system protoype for site-specific soil management.	Australian Research Council SPIRT	2001-2003	195
Assoc. Professor Alex McBratney	The University of Sydney	Development of precision agriculture in the grain industry.	GRDC	2002-2007	172
Dr. Michael Bange/ Dirk Richards	CSIRO Plant Industry	Application of crop simulation within the Australian Cotton Industry.	CRDC	2001-2004	355
Dr. Michael Bange/ Stephen Milroy	CSIRO Plant Industry	The impact of temperature extremes on cotton performance	CRDC	2001-2004	338
Dr. Michael Bange/ Darren Linsley	CSIRO Plant Industry	Supporting development and independent evaluation of cotton management packages	CRDC	2002-2005	310
Dr. Michael Bange/ Tony Pfeiffer	CSIRO Plant Industry	ACRI Computing Support	CRDC	2002-2005	403
Dr. Michael Bange/ Sandra Deutscher	CSIRO Plant Industry	Delivering science to Agribusiness – novel decision support tools CRDC Component	CRDC	2003-2006	200
Dr Michael Bange/Sandra Deutscher	CSIRO PI	Continued development and field evaluation of micro-computer cotton management packages.	CRDC	2000-2003	396

Dr Michael Bange	CSIRO PI	Enhanced Access to climate and weather data.	CRDC	2000-2003	145
Dr Geoff Naylor	CSIRO TFT	Cotton fineness and maturity using the Sirolan-Laserscan	CRDC	2001-2003	145
Dr Geoff Naylor	CSIRO TFT	Participation in an international interlaboratory trial to develop standard reference cotton samples for fineness and maturity	CRDC	2001-2003	80
G Strickland	WA Department of Agriculture	Preparation for release of biological control insects for temperate pasture weeds	Meat & Livestock Australia	2002-03	9
G Strickland	WA Department of Agriculture	Development of sustainable pest management practices for Bollgard II® production in the Kimberley.	CRDC	2002-04	226
N. Reid, I. Reeve, D. Curtis	The University of New England	Creating inspiration: how visual and performing arts shape environmental behaviour	LWRRDC UNE 44	2002-2005	270
N. Reid	The University of New England	Profitable Biodiverse Wool Production Systems for the Northern Tablelands of NSW	Land, Water & Wool, LWRRDC UNE 43	2002-2006	300
N. Reid	John and Annette Cassidy, Merilba Partnership	Herbicidal Control of Box Mistletoe on Farm Eucalypts		2003	55
N. Reid, I. Reeve, D. Curtis	Rural Industries Research & Development Corporation	Creating inspiration: how visual and performing arts shape environmental behaviour	UNE0-85A	2003-2005	30



Performance Indicators

Performance Indicator	1999-2000	2000-2001	2001-2002	2002-2003
Addressing industry need - Quality and relevance of the research program				
Number of publications				
- Refereed Journal	28	18	20	20
- Book Chapters	3	5	7	8
- Conference papers	31	25	14	68
Number of Research Reference Reports	10	7	11	30
Number of Conference Presentations	24	47	27	22
Number of Seminars and Workshops	100	84	34	76
Number of Trade Shows participated in	2	3	2	2
Number of Grower Magazine articles produced	40	31	24	34
Number of Media Releases	27	36	20	22
Number of Visitors to the CRC	15	19	26	14
Number of Public Relations exercises completed	1	8	11	29
Number of Media Interviews	18		34	31
Number of Awards and Prises.	6	2	2	11
Number of clients on Industry database	2,600	2,730	2,804	2,804
Number of hits per day taken on the CRC website.	400	540	540	540
Number of projects				
Program 1 – Growth in northern Australia	3	4	3	3
Program 2 – Innovative Technologies	9	8	7	7
Program 3 – Sustainable Farming Systems	19	21	27	29
Program 4 – Education and Training	18	15	20	19
Program 5 – Cotton Textile Research	2	3	3	3
Contribution to Australia's sustainable economic and social development				
These indicators can only be reported upon by examples. As we approach the fifth-year review we are completing an independent assessment of our performance in this area.				
Use and Commercialisation of research outputs				
Number of patents				1
Number of Business Plans completed				1
Number of Documents produced from research outputs in response to industry needs	18	18	15	11

Registered Users of EntoPAK	800	872	936	871
Registered Users of NutriPAK			533	675
Registered Users of SoilPAK	450	532	623	698
Registered Users of MachinePAK			408	408
Registered Users of SWprayPAK				463
Registered Users of IDM Guidelines				516
Registered Users of WeedPAK				610
Registered Users of CottonPAK CD				383
Registered Users of CottonLOGIC	800	800	800	800
Education and training				
Number of students graduated from the Cotton production Course	30	20	35	21
Number of CRC staff delivering specialised lectures during residential schools.	30	30	30	30
Number of scholarships and supporting grants awarded and total value	10	10	10	10
Percentage of research students with a non-university supervisor or co-supervisor	34.6%	29%	42%	40.5%
Percentage of students spending time on relevant projects in the industry sector	100%	100%	100%	100%
Number of students involved in professional development courses	0	0	6	3
Number of Industry Development Officers	10	8	10	10
Number of Water Use Efficiency Extension Officers	5	6	11	7
Number of Farming System Extension Officers	7	7	7	7
Number of CottonLOGIC Specialised Support Officers	1	1	1	1
Number of IPM Training Coordinators	1	1	1	1
Number of Trainee Industry Development Officers.	1	1	2	2
Number of National Extension Coordinators	1	1	1	1
Number of Program Coordinators Best Management Practice	1	1	1	1
Number of IPM short courses and growers completing.			3 pilot IPM Short courses 34 growers & consultants completed.	6 courses conducted. 66 growers & consultants attended

Number of CottonLOGIC Workshops completed	20	17	11	11
Value of in-kind devoted to Technology Transfer and Communications.	$1.9604 m	$2.378 m	$2.485 m	$2.792 m
Value of Cash spent on Education and Technology Transfer.	$0.2146 m	$0.523 m	$0.499 m	$0.402 m
Collaborative arrangements				
Percentage of projects with participants from >2 partners	40%	69%	69%	69%
Number of projects with non-CRC collaborators				
- Nationally	30	51	48	51
- Internationally	3	7	11	10
Number of International Scientific Exchanges completed	5	5	5	4
Resources and Budget				
Total income (cash & in-kind)	$15.212 m	$16,162 m	$16.989 m	$17.925 m
FTE research staff (excluding students)	47.84	53.50	50.14	52.41
FTE technical and support staff	48.41	43.50	50.35	50.61
Total Cash resources	$5.092 m	$5.033 m	$5.850 m	$5.712 m
Total cash contribution from sources other than AusIndustry	$3.092 m	$2.833 m	$3.650 m	$3.612 m
Total funding secured from Cotton Research & development Corporation	$0.995 m	$1.227 m	$1.707 m	$1.742 m
Total additional external grants relevant to the CRC's goals received by CRC staff	$1.239 m	$0.838	$1.118 m	$0.838 m
Leverage (total funds v AusIndustry funding)	> 7.6	> 7.3	> 7.7	> 8.5
Management structure and arrangements				
Majority of Board members independent of research providers	7/12	7/12	7/12	7/12
Management Committee established	✓	✓	✓	✓
Advisory Committee established	✓	✓	✓	✓
Northern Committee established	✓	✓	✓	✓
Financial reports delivered Quarterly to the Board.	✓	✓	✓	✓
Annual Report submitted	3rd Qtr	3rd Qtr	3rd Qtr	2nd Qtr

Financial Statements

RESEARCH STAFF RESOURCES

ATTACHMENT B

IN-KIND CONTRIBUTION BY ORGANISATION (PERSON YEARS) 2002/2003

				Main Activity	Total % of Time	% Spent on Research Program Sub-Program P 1	P 2	P 3	P 5	Total on Research	% Spent on Education Program	% Spent External Communications	% Spent Technology Transfer	% Spent on CRC Administration
Agriculture Western Australia														
Researcher														
Annells	Amanda	Dr	R	100%	100%	0%	0%	0%	100%	0%	0%	0%	0%	
Moulden	John	Mr	R	60%	60%	0%	0%	0%	60%	0%	0%	0%	0%	
Strickland	Geoff	Mr	R	80%	80%	0%	0%	0%	80%	0%	0%	0%	0%	
					2.40	*2.40*	*0.00*	*0.00*	*0.00*	*2.40*	*0.00*	*0.00*	*0.00*	*0.00*
Cotton Research & Development Corporation														
Researcher														
Dugdale	Helen	Ms	T	9%	0%	0%	8%	0%	8%	0%	0%	1%	0%	
Holloway	Rachel	Ms	T	11%	0%	0%	0%	0%	0%	0%	0%	11%	0%	
Lester	Tim	Mr	T	3%	0%	0%	0%	0%	0%	0%	0%	3%	0%	
McLean	Jodi	Ms	T	8%	0%	0%	4%	0%	4%	0%	0%	4%	0%	
Pyke	Bruce	Mr	T	25%	0%	0%	0%	0%	0%	0%	0%	25%	0%	
Roth	Guy	Mr	T	23%	0%	0%	13%	0%	13%	5%	0%	5%	0%	
Schulze	Ralph	Mr	T	8%	0%	0%	0%	0%	0%	0%	0%	8%	0%	
Tingay	Sonia	Ms	T	3%	0%	0%	0%	0%	0%	0%	0%	3%	0%	
					0.89	*0.00*	*0.00*	*0.24*	*0.00*	*0.24*	*0.05*	*0.00*	*0.58*	*0.00*
Cotton Seed Distributors														
Researcher														
Allen	Stephen	Dr	R	50%	0%	20%	20%	0%	40%	5%	0%	5%	0%	
Eveleigh	Robert	Mr	T	15%	0%	0%	0%	0%	0%	0%	0%	15%	0%	
Kauter	Greg	Mr	T	25%	0%	0%	0%	0%	0%	0%	0%	25%	0%	
Kay	Adam	Mr	T	15%	0%	0%	0%	0%	0%	0%	0%	15%	0%	
Marshall	John	Mr	T	15%	0%	0%	0%	0%	0%	0%	0%	15%	0%	
					1.20	*0.00*	*0.20*	*0.20*	*0.00*	*0.40*	*0.05*	*0.00*	*0.75*	*0.00*
CSIRO Entomology														
Researcher														
Akhurst	Ray	Dr	R	10%	0%	10%	0%	0%	10%	0%	0%	0%	0%	
Baker	Geoff	Dr	R	80%	0%	40%	40%	0%	80%	0%	0%	0%	0%	
Bird	Lisa	Ms	R	38%	0%	38%	0%	0%	38%	0%	0%	0%	0%	
De Barro	Paul	Dr	R	30%	0%	30%	0%	0%	30%	0%	0%	0%	0%	
Dillon	Martin	Mr	R	100%	0%	0%	90%	0%	90%	10%	0%	0%	0%	
Mahon	Rod	Dr	R	80%	0%	80%	0%	0%	80%	0%	0%	0%	0%	
Oakeshott	John	Dr	R	30%	0%	30%	0%	0%	30%	0%	0%	0%	0%	
Olsen	Karen	Ms	R	50%	0%	50%	0%	0%	50%	0%	0%	0%	0%	
Whitehouse	Mary	Dr	R	85%	0%	0%	85%	0%	85%	0%	0%	0%	0%	
					5.03	*0.00*	*2.78*	*2.15*	*0.00*	*4.93*	*0.10*	*0.00*	*0.00*	*0.00*
CSIRO Plant Industry														
Researcher														
Bange	Michael	Dr	R	40%	30%	0%	0%	0%	30%	5%	0%	5%	0%	
Brown	Tony	Dr	R	10%	0%	10%	0%	0%	10%	0%	0%	0%	0%	
Brubaker	Curt	Dr	R	30%	0%	30%	0%	0%	30%	0%	0%	0%	0%	
Constable	Greg	Dr	R	20%	0%	0%	20%	0%	20%	0%	0%	0%	0%	
Deutscher	Sandra	Ms	T	40%	0%	0%	0%	0%	0%	0%	0%	40%	0%	
Duggan	Brian	Dr	R	100%	100%	0%	0%	0%	100%	0%	0%	0%	0%	

			Main Activity	Total % of Time	% Spent on Research Program Sub-Program P 1	P 2	P 3	P 5	Total on Research	% Spent on Education Program	% Spent External Communications	% Spent Technology Transfer	% Spent on CRC Administration
Johnston	Scott	Mr	T	40%	0%	0%	0%	0%	0%	0%	0%	40%	0%
Johnston	David	Mr	T	40%	0%	0%	0%	0%	0%	0%	0%	40%	0%
Lei	Tom	Dr	R	40%	0%	0%	40%	0%	40%	0%	0%	0%	0%
Linsley	Darren	Mr	T	40%	0%	0%	0%	0%	0%	0%	0%	40%	0%
Milroy	Steve	Dr	R	40%	0%	0%	40%	0%	40%	0%	0%	0%	0%
Neilsen	James	Mr	R	20%	0%	0%	20%	0%	20%	0%	0%	0%	0%
Pfeiffer	Tony	Mr	T	40%	0%	0%	0%	0%	0%	0%	0%	40%	0%
Reddall	Amellia	Dr	R	20%	0%	0%	20%	0%	20%	0%	0%	0%	0%
Reid	Peter	Mr	R	20%	0%	0%	20%	0%	20%	0%	0%	0%	0%
Richards	Dirk	Mr	R	20%	0%	0%	20%	0%	20%	0%	0%	0%	0%
Stiller	Warwick	Dr	R	20%	0%	0%	20%	0%	20%	0%	0%	0%	0%
Tennakoon	Sunil	Dr	R	40%	0%	0%	40%	0%	40%	0%	0%	0%	0%
Wilson	Lewis	Dr	R	40%	0%	0%	35%	0%	35%	5%	0%	0%	0%
				6.60	*1.30*	*0.40*	*2.75*	*0.00*	*4.45*	*0.10*	*0.00*	*2.05*	*0.00*
CSIRO Sustainable Ecosystems													
Researcher													
Carberry	Peter	Dr	R	20%	0%	0%	10%	0%	10%	0%	0%	10%	0%
Dalgleish	Neil	Dr	R	30%	0%	0%	20%	0%	20%	0%	0%	10%	0%
Hochman	Zvi	Dr	R	20%	0%	0%	10%	0%	10%	0%	0%	10%	0%
Probert	Merv	Dr	R	10%	0%	0%	10%	0%	10%	0%	0%	0%	0%
Whish	Jeremy	Dr	R	20%	0%	0%	20%	0%	20%	0%	0%	0%	0%
				1.00	*0.00*	*0.00*	*0.70*	*0.00*	*0.70*	*0.00*	*0.00*	*0.30*	*0.00*
CSIRO Textile & Fibre Technology													
Researcher													
Evans	David	Dr	R	15%	0%	0%	0%	15%	15%	0%	0%	0%	0%
Gordon	Stuart	Dr	R	30%	0%	0%	0%	30%	30%	0%	0%	0%	0%
King	David	Dr	R	13%	0%	0%	0%	13%	13%	0%	0%	0%	0%
Naylor	Geoff	Dr	R	35%	0%	0%	0%	35%	35%	0%	0%	0%	0%
Prins	Martin	Mr	R	15%	0%	0%	0%	15%	15%	0%	0%	0%	0%
				1.08	*0.00*	*0.00*	*0.00*	*1.08*	*1.08*	*0.00*	*0.00*	*0.00*	*0.00*
Dept of Business, Industry & Resource Development													
Researcher													
Bellgard	Stan	Dr	R	20%	20%	0%	0%	0%	20%	0%	0%	0%	0%
Bennett	Malcolm	Mr	R	20%	20%	0%	0%	0%	20%	0%	0%	0%	0%
Dougall	Andrew	Mr	R	80%	80%	0%	0%	0%	80%	0%	0%	0%	0%
Eastick	Rowena	Ms	R	20%	20%	0%	0%	0%	20%	0%	0%	0%	0%
Ham	Christop	Mr	R	10%	10%	0%	0%	0%	10%	0%	0%	0%	0%
Martin	Colin	Dr	R	75%	75%	0%	0%	0%	75%	0%	0%	0%	0%
				2.25	*2.25*	*0.00*	*0.00*	*0.00*	*2.25*	*0.00*	*0.00*	*0.00*	*0.00*
Dept Primary Industries Qld													
Researcher													
Franzmann	Bernie	Dr	R	90%	0%	0%	80%	0%	80%	10%	0%	0%	0%
Gordon	Ian	Mr	R	10%	10%	0%	0%	0%	10%	0%	0%	0%	0%
Goyne	Phil	Dr	R	25%	0%	0%	0%	0%	0%	0%	0%	25%	0%
Grundy	Paul	Dr	R	50%	0%	50%	0%	0%	50%	0%	0%	0%	0%
Harris	Graham	Mr	T	50%	0%	0%	0%	0%	0%	0%	0%	50%	0%
Hauxwell	Carrie	Dr	R	50%	0%	50%	0%	0%	50%	0%	0%	0%	0%
Holdom	David	Mr	R	45%	0%	0%	45%	0%	45%	0%	0%	0%	0%
Hughes	Peter	Mr	T	60%	0%	0%	0%	0%	0%	0%	0%	60%	0%
Kelly	David	Mr	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Khan	Moazzem	Dr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%

			Main Activity	Total % of Time	% Spent on Research Program Sub-Program P 1	P 2	P 3	P 5	Total on Research	% Spent on Education Program	% Spent External Communications	% Spent Technology Transfer	% Spent on CRC Administration
Kleinmeulm	Paul	Mr	R	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Kochman	Joe	Dr	R	40%	0%	20%	20%	0%	40%	0%	0%	0%	0%
McIntyre	Geoff	Mr	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
McLennan	Austin	Mr	R	50%	0%	0%	50%	0%	50%	0%	0%	0%	0%
Meinke	Holger	Mr	R	40%	0%	0%	40%	0%	40%	0%	0%	0%	0%
Miles	Melina	Dr	R	25%	0%	0%	25%	0%	25%	0%	0%	0%	0%
Moore	Chris	Dr	R	50%	0%	50%	0%	0%	50%	0%	0%	0%	0%
Moss	James	Mr	R	20%	10%	0%	10%	0%	20%	0%	0%	0%	0%
Murray	David	Dr	R	30%	0%	0%	30%	0%	30%	0%	0%	0%	0%
Osten	Vicki	Ms	R	10%	0%	0%	10%	0%	10%	0%	0%	0%	0%
Salmond	Greg	Mr	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Scholz	Brad	Dr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Sequeira	Richard	Dr	R	10%	10%	0%	0%	0%	10%	0%	0%	0%	0%
Silburn	Mark	Mr	T	20%	0%	0%	20%	0%	20%	0%	0%	0%	0%
Smith	Linda	Ms	R	25%	0%	0%	25%	0%	25%	0%	0%	0%	0%
Smith	Rebecca	Ms	R	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Smith	Lawrenc	Mr	R	50%	0%	0%	50%	0%	50%	0%	0%	0%	0%
Sullivan	Anne	Ms	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Swan	Linda	Ms	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Titmarsh	Ian	Dr	R	10%	10%	0%	0%	0%	10%	0%	0%	0%	0%
Walker	Steve	Mr	R	10%	0%	0%	10%	0%	10%	0%	0%	0%	0%
Waters	David	Mr	R	10%	0%	0%	10%	0%	10%	0%	0%	0%	0%
				16.80	*0.40*	*1.70*	*7.25*	*0.00*	*9.35*	*0.10*	*0.00*	*7.35*	*0.00*

NSW Agriculture

Researcher

Charles	Graham	Mr	R	65%	0%	0%	60%	0%	60%	5%	0%	0%	0%
Cottage	Emma	Ms	R	40%	0%	0%	40%	0%	40%	0%	0%	0%	0%
Farquhars	Bob	Mr	R	25%	0%	0%	25%	0%	25%	0%	0%	0%	0%
Gibb	Dallas	Mr	R	75%	0%	0%	0%	0%	0%	15%	0%	60%	0%
Gibson	Trevor	Dr	R	10%	0%	0%	0%	0%	0%	0%	0%	10%	0%
Gunning	Robin	Dr	R	50%	0%	0%	50%	0%	50%	0%	0%	0%	0%
Heimoana	Viliami	Mr	R	100%	0%	0%	90%	0%	90%	10%	0%	0%	0%
Herron	Grant	Dr	T	60%	0%	0%	0%	0%	0%	0%	0%	60%	0%
Hickman	Mark	Mr	T	70%	0%	0%	0%	0%	0%	0%	0%	70%	0%
Hulugalle	Nilantha	Dr	R	70%	0%	0%	65%	0%	65%	5%	0%	0%	0%
Jenkins	Leigh	Ms	T	50%	0%	0%	0%	0%	0%	0%	0%	50%	0%
Jhorar	Om	Dr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Mensah	Robert	Dr	R	50%	0%	45%	0%	0%	45%	5%	0%	0%	0%
Nehl	David	Dr	R	65%	5%	20%	30%	0%	55%	5%	0%	5%	0%
Rossiter	Louise	Dr	R	25%	0%	0%	25%	0%	25%	0%	0%	0%	0%
Rourke	Kirrily	Ms	T	20%	0%	0%	0%	0%	0%	0%	0%	20%	0%
Schulze	Klara	Ms	T	30%	0%	0%	0%	0%	0%	0%	0%	30%	0%
Smith	Peter	Mr	T	20%	0%	0%	0%	0%	0%	0%	0%	20%	0%
Spora	Annie	Ms	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Swann	Barry	Mr	T	50%	0%	0%	0%	0%	0%	0%	0%	50%	0%
Sykes	Sarah	Ms	T	20%	0%	0%	0%	0%	0%	0%	0%	20%	0%
Vancov	Tony	Dr	R	20%	0%	0%	20%	0%	20%	0%	0%	0%	0%
				11.15	*0.05*	*0.65*	*5.05*	*0.00*	*5.75*	*0.45*	*0.00*	*4.95*	*0.00*

The University of New England

Researcher

Backhouse	David	Dr	R	20%	0%	0%	20%	0%	20%	0%	0%	0%	0%
Blair	Graeme	A/Pr	R	3%	0%	0%	3%	0%	3%	0%	0%	0%	0%

			Main Activity	Total % of Time	% Spent on Research Program Sub-Program P 1	P 2	P 3	P 5	Total on Research	% Spent on Education Program	% Spent External Communications	% Spent Technology Transfer	% Spent on CRC Administration
Daniel	Heiko	Dr	R	10%	0%	0%	10%	0%	10%	0%	0%	0%	0%
Faulkner	Richard	A/Pr	R	10%	0%	0%	10%	0%	10%	0%	0%	0%	0%
Gregg	Peter	A/Pr	R	50%	0%	30%	10%	0%	40%	10%	0%	0%	0%
Jessop	Robin	A/Pr	R	20%	0%	0%	0%	0%	0%	20%	0%	0%	0%
Johnson	Stephen	Dr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Reid	Nick	A/Pr	R	30%	0%	0%	30%	0%	30%	0%	0%	0%	0%
Sindel	Brian	Dr	R	15%	0%	0%	15%	0%	15%	0%	0%	0%	0%
				2.58	*0.00*	*0.30*	*1.98*	*0.00*	*2.28*	*0.30*	*0.00*	*0.00*	*0.00*
The University of Sydney													
Researcher													
Campbell	Lindsay	Dr	R	15%	0%	0%	15%	0%	15%	0%	0%	0%	0%
Cattle	Stephen	Dr	R	10%	0%	0%	10%	0%	10%	0%	0%	0%	0%
Copeland	Les	Prof	R	10%	0%	0%	10%	0%	10%	0%	0%	0%	0%
Kennedy	Ivan	Prof	R	25%	0%	0%	20%	0%	20%	5%	0%	0%	0%
Lyon	Bruce	Dr	R	20%	0%	15%	0%	0%	15%	5%	0%	0%	0%
McBratney	Alex	Prof	R	30%	0%	0%	25%	0%	25%	5%	0%	0%	0%
Singh	Balwant	Dr	R	10%	0%	0%	10%	0%	10%	0%	0%	0%	0%
Vervoort	Willem	Dr	R	25%	0%	0%	25%	0%	25%	0%	0%	0%	0%
				1.45	*0.00*	*0.15*	*1.15*	*0.00*	*1.30*	*0.15*	*0.00*	*0.00*	*0.00*
Grand Total				*52.41*	*6.40*	*6.18*	*21.47*	*1.08*	*35.12*	*1.30*	*0.00*	*15.98*	*0.00*

ATTACHMENT B

COTTON CRC AND CASH FUNDED RESEARCH STAFF BY ORGANISATION (Person Years)

			Main Activity	Total % of Time	% Spent on Research Program Sub-Program P 1	P 2	P 3	P 5	Total on Research	% Spent on Education Program	% Spent External Communications	% Spent Technology Transfer	% Spent on CRC Administration
CRC for Greenhouse Accounting													
Researcher													
Grace	Peter	Dr	R	50%	0%	0%	50%	0%	50%	0%	0%	0%	0%
				0.50	*0.00*	*0.00*	*0.50*	*0.00*	*0.50*	*0.00*	*0.00*	*0.00*	*0.00*
CSIRO Entomology													
Researcher													
Fitt	Gary	Dr	R	100%	0%	0%	0%	0%	0%	0%	0%	0%	100%
Hardwick	Scott	Dr	R	50%	0%	0%	50%	0%	50%	0%	0%	0%	0%
Mansfield	Sarah	Dr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
				2.50	*0.00*	*0.00*	*1.50*	*0.00*	*1.50*	*0.00*	*0.00*	*0.00*	*1.00*
CSIRO Plant Industry													
Researcher													
Orman	Kym	Ms	A	100%	0%	0%	0%	0%	0%	0%	0%	0%	100%
Roberts	Grant	Mr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%

			Main Activity	Total % of Time	% Spent on Research Program Sub-Program P 1	P 2	P 3	P 5	Total on Research	% Spent on Education Program	% Spent External Communications	% Spent Technology Transfer	% Spent on CRC Administration
Rochester	Ian	Dr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Schick	Nicky	Ms	T	100%	0%	0%	0%	0%	0%	0%	0%	0%	100%
Whiteside	Stewart	Mr	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Worth	Jeff	Mr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Yeates	Stephen	Mr	R	100%	100%	0%	0%	0%	100%	0%	0%	0%	0%
				7.00	*1.00*	*0.00*	*3.00*	*0.00*	*4.00*	*0.00*	*0.00*	*1.00*	*2.00*
CSIRO Textile & Fibre Technology													
Researcher													
Cai	Jackie	Dr	R	100%	0%	0%	0%	100%	100%	0%	0%	0%	0%
van der Sluijs	Rene	Mr	R	50%	0%	0%	0%	50%	50%	0%	0%	0%	0%
				1.50	*0.00*	*0.00*	*0.00*	*1.50*	*1.50*	*0.00*	*0.00*	*0.00*	*0.00*
Dept Natural Resources Qld													
Researcher													
Zischke	Rachael	Ms	R	50%	0%	0%	50%	0%	50%	0%	0%	0%	0%
				0.50	*0.00*	*0.00*	*0.50*	*0.00*	*0.50*	*0.00*	*0.00*	*0.00*	*0.00*
Dept of Business, Industry & Resource Development													
Researcher													
Ward	Andrew	Dr	R	81%	81%	0%	0%	0%	81%	0%	0%	0%	0%
				0.81	*0.81*	*0.00*	*0.00*	*0.00*	*0.81*	*0.00*	*0.00*	*0.00*	*0.00*
Dept Primary Industries Qld													
Researcher													
Anderson	Toni	Ms	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Christian	Ingrid	Ms	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Ginns	Stephen	Mr	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Goyne	Phil	Dr	T	75%	0%	0%	0%	0%	0%	0%	0%	75%	0%
Hare	Janelle	Ms	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Harris	Graham	Mr	T	50%	0%	0%	0%	0%	0%	0%	0%	50%	0%
Hickman	Mark	Mr	T	30%	0%	0%	0%	0%	0%	0%	0%	30%	0%
Hood	Sarah	Ms	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Spragge	Andres	Mr	T	50%	0%	0%	0%	0%	0%	0%	0%	50%	0%
Wang	Ertong	Dr	R	75%	0%	75%	0%	0%	75%	0%	0%	0%	0%
Whiteoak	Olivia	Ms	T	95%	0%	0%	0%	0%	0%	0%	0%	95%	0%
Wigginton	David	Mr	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Wu	Hanwen	Dr	R	25%	0%	0%	25%	0%	25%	0%	0%	0%	0%
				10.00	*0.00*	*0.75*	*0.25*	*0.00*	*1.00*	*0.00*	*0.00*	*9.00*	*0.00*
NSW Agriculture													
Researcher													
Brown	Evan	Mr	T	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Dang	Ho	Dr	R	100%	0%	100%	0%	0%	100%	0%	0%	0%	0%
Hoque	Ziaul	Mr	R	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Larsen	David	Mr	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
O'Halloran	Julie	Ms	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%

			Main Activity	Total % of Time	% Spent on Research Program Sub-Program P 1	P 2	P 3	P 5	Total on Research	% Spent on Education Program	% Spent External Communications	% Spent Technology Transfer	% Spent on CRC Administration
Taylor	Ian	Dr	R	80%	0%	0%	80%	0%	80%	0%	0%	0%	0%
van Dongn	Penny	Ms	R	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
				6.80	*0.00*	*1.00*	*1.80*	*0.00*	*2.80*	*0.00*	*0.00*	*4.00*	*0.00*
The University of New England													
Researcher													
Del Socorro	Alice	Dr	R	90%	0%	90%	0%	0%	90%	0%	0%	0%	0%
Downey	Adam	Mr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Kent	Richard	Mr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Moore	C	Dr	R	10%	0%	10%	0%	0%	10%	0%	0%	0%	0%
Renchen	Ingrid	Ms	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Silberbauer	Letitia	Dr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Stanley	John	Dr	T	100%	0%	0%	0%	0%	0%	0%	0%	100%	0%
				6.00	*0.00*	*1.00*	*4.00*	*0.00*	*5.00*	*0.00*	*0.00*	*1.00*	*0.00*
The University of Queensland													
Researcher													
Gulino	Lisa	Ms	R	100%	0%	100%	0%	0%	100%	0%	0%	0%	0%
Harvey	John	Mr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
				2.00	*0.00*	*1.00*	*1.00*	*0.00*	*2.00*	*0.00*	*0.00*	*0.00*	*0.00*
The University of Sydney													
Researcher													
Collinge	Derek	Mr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Crossan	Angus	Dr	R	50%	0%	0%	50%	0%	50%	0%	0%	0%	0%
Field	Damien	Dr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Odeh	Inakwu	Dr	R	90%	0%	0%	90%	0%	90%	0%	0%	0%	0%
Onus	Alex	Mr	R	50%	0%	0%	50%	0%	50%	0%	0%	0%	0%
Rose	Michael	Mr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Speirs	Simon	Mr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Triantafilis	John	Dr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Vanags	Chris	Mr	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Whiffen	Leonie	Ms	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
Yan	Florian	Ms	R	100%	0%	0%	100%	0%	100%	0%	0%	0%	0%
				9.90	*0.00*	*0.00*	*9.90*	*0.00*	*9.90*	*0.00*	*0.00*	*0.00*	*0.00*
Grand Total				*47.51*	*1.81*	*3.75*	*22.45*	*1.50*	*29.51*	*0.00*	*0.00*	*15.00*	*3.00*

ATTACHMENT B

SUPPORT STAFF

Contributed			CRC Funded (by employing organisation)	
Organisation	No. Staff (person years)		Organisation	No. Staff (person years)
Agriculture WA	1.45		CRC Greenhouse Accounting	0.08
Cotton Research & Development Corporation	0.00		Cotton Research & Development Corporation	0.00
Cotton Seed Distributors	0.30		Cotton Seed Distributors	0.00
CSIRO	14.08		CSIRO	10.50
Dept. Primary Industries, Qld	8.40		Dept. Primary Industries, Qld	1.10
NSW Agriculture	7.60		NSW Agriculture	3.00
NTDPIF	1.50		NTDPIF	1.20
Queensland Cotton	0.00		Queensland Cotton	0.00
University of New England	0.90		University of New England	0.50
University of Sydney	0.00		University of Sydney	0.00
WAI	0.00		WAI	0.00
TOTAL	34.23		TOTAL	16.38

ATTACHMENT B

SUMMARY OF CONTRIBUTIONS IN PERSON YEARS

	Total Equivalent Person Years	Person Years Spent on Research Program					% Spent on Education Program	% Spent on External Communication	% Spent on Technology Transfer	% Spent on CRC Admin.
		Sub-program				Total on Research				
		1	2	3	5					
TOTAL CONTRIBUTED	52.41	6.40	6.18	21.47	1.08	35.12	1.30	0.00	15.98	0.00
TOTAL FUNDED BY CRC	47.51	1.81	3.75	22.45	1.50	29.51	0.00	0.00	15.00	3.00
GRAND TOTAL	99.92	8.21	9.93	43.92	2.58	64.63	1.30	0.00	30.98	3.00
Proportion of total professional staff resources in each activity	100%	8.22%	9.94%	43.95%	2.58%	64.68%	1.3%	0.0%	31.00%	3.00%

IN-KIND CONTRIBUTIONS FROM PARTICIPANTS (DOLLARS IN '000's)

TABLE 1

	EXPENDITURE						EXPENDITURE											
	2002/03		2001/02		2000/01		1999/00		CUMULATIVE TOTAL TO DATE		2003/04	2004/05	2005/06	GRAND TOTAL Total	Agr'mt	Diff
	Actual	Agr'mt	Actual	Agr'mt	Actual	Agr'mt	Actual	Agr'mt	Actual	Agr'mt	Agr'mt	Agr'mt	Agr'mt	7 years	7 years	7 years
CSIRO																
Salaries	1,979	1,234	1,741	1,250	1,922	1,271	1,367	1,239	7,009	3,760	1,234	1,234	1,234	10,711	7,462	3,249
Capital	0	0	0	0	0	0	0		0	0				0	0	0
Other	1,586	1,120	1,705	1,140	1,737	1,157	1,162	1,129	6,190	3,426	1,120	1,120	1,120	9,550	6,786	2,764
Total	3,565	2,354	3,446	2,390	3,659	2,428	2,529	2,368	13,199	7,186	2,354	2,354	2,354	16,763	16,602	161
NSW Agriculture																
Salaries	1,254	1,029	1,109	1,029	1,108	1,029	1,086	1,029	4,557	3,087	1,029	1,029	1,029	7,644	6,174	1,470
Capital	0	0	0	0	0	0	0		0	0				0	0	0
Other	967	1,029	966	1,029	967	1,029	967	1,029	3,867	3,087	1,029	1,029	1,029	6,954	6,174	780
Total	2,221	2,058	2,075	2,058	2,075	2,058	2,052	2,058	8,423	6,174	2,058	2,058	2,058	14,400	14,406	-6
Qld Dept Primary Industries																
Salaries	1,692	945	1,276	945	1,128	945	1,195	945	5,291	2,835	945	945	945	8,126	5,670	2,456
Capital		0		0	0	0	0		0	0				0	0	0
Other	1,952	1,186	1,447	1,186	1,381	1,186	1,344	1,186	6,124	3,558	1,186	1,186	1,186	9,682	7,116	2,566
Total	3,644	2,131	2,723	2,131	2,509	2,131	2,539	2,131	11,415	6,393	2,131	2,131	2,131	15,325	14,917	408
Agriculture WA																
Salaries	253	281	261	281	287	281	270	281	1,071	843	281	281	281	1,914	1,686	228
Capital	0	0	0	0	0	0	0		0	0				0	0	0
Other	317	285	317	315	317	319	372	372	1,323	1,006	275	265	215	2,078	1,761	317
Total	570	566	578	596	604	600	642	653	2,394	1,849	556	546	496	4,002	4,013	-11
NT Dept of Business, Industry & Resource Development																
Salaries	282	211	262	211	267	211	276	211	1,087	633	211	211	211	1,720	1,266	454
Capital	0	0	0	0	0	0	0		0	0				0	0	0
Other	205	152	190	152	150	152	166	152	711	456	152	152	152	1,167	912	255
Total	487	363	452	363	417	363	442	363	1,798	1,089	363	363	363	2,620	2,541	79
The University of Sydney																
Salaries	161	130	182	130	171	130	136	130	650	390	130	130	130	1,040	780	260
Capital		0		0		0	0		0	0				0	0	0
Other	279	224	315	224	295	224	235	224	1,124	672	224	224	224	1,796	1,344	452
Total	440	354	497	354	466	354	371	354	1,774	1,062	354	354	354	2,495	2,478	17
The University of New England																
Salaries	580	292	605	292	467	292	502	292	2,154	876	292	292	292	3,030	1,752	1,278
Capital	0	0	0	0	0	0	0		0	0				0	0	0
Other	238	221	260	221	230	221	236	221	964	663	221	221	221	1,627	1,326	301
Total	818	513	865	513	697	513	738	513	3,118	1,539	513	513	513	3,816	3,591	225
CRDC																
Salaries	80	62	70	62	70	62	69	62	289	186	62	62	62	475	372	103
Capital	0	0	0	0	0	0	0		0	0				0	0	0
Other	50	39	44	39	44	39	43	39	181	117	39	39	39	298	234	64
Total	130	101	114	101	114	101	112	101	470	303	101	101	101	718	707	11
Cotton Seed Distributors																
Salaries	154	113	149	113	182	113	151	113	636	339	113	113	113	975	678	297
Capital	0	0	0	0	0	0	0		0	0				0	0	0
Other	184	134	178	134	208	134	174	134	744	402	134	134	134	1,146	804	342
Total	338	247	327	247	390	247	325	247	1,380	741	247	247	247	1,807	1,729	78
Queensland Cotton																
Salaries	0	31	12	31	35	31	7	31	54	93	31	31	31	147	186	-39
Capital	0	0	0	0	0	0	0		0	0				0	0	0
Other	0	25	10	25	27	25	6	25	43	75	25	25	25	118	150	-32
Total	0	56	22	56	62	56	13	56	97	168	56	56	56	349	392	-43
Western Agricultural Industries																
Salaries	0	68	12	68	70	68	52	68	134	204	68	68	68	338	408	-70
Capital	0	0	0	0	0	0	0		0	0				0	0	0
Other	0	57	28	57	66	57	46	57	140	171	57	57	57	311	342	-31
Total	0	125	40	125	136	125	98	125	274	375	125	125	125	848	875	-27
Twynam Cotton																
Salaries	0	120	0	120	0	120	157	120	157	360	120	120	120	517	720	-203
Capital	0	0	0	0	0	0	0		0	0				0	0	0
Other	0	65	0	65	0	65	101	65	101	195	65	65	65	296	390	-94
Total	0	185	0	185	0	185	258	185	258	555	185	185	185	1,368	1,295	73
TOTAL IN-KIND CONTRIBUTIONS																
Salaries	6,435	4,516	5,679	4,532	5,707	4,553	5,267	4,521	16,653	13,606	4,516	4,516	4,516	34,717	31,670	3,047
Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	5,778	4,537	5,460	4,587	5,422	4,608	4,853	4,633	15,735	13,828	4,527	4,517	4,467	33,783	31,876	1,907
GRAND TOTAL (IN-KIND) (T1)	12,213	9,053	11,139	9,119	11,129	9,161	10,120	9,154	32,388	27,434	9,043	9,033	8,983	64,512	63,546	4,954

TABLE 2

CASH CONTRIBUTIONS (DOLLARS IN '000s)

PARTICIPANT	ACTUAL 2002/03		ACTUAL 2001/02		ACTUAL 2000/01		ACTUAL 1999/00		CUMULATIVE TOTAL TO DATE		2003/04	2004/05	2005/06	Total	GRAND TOTAL	
	Actual	Agr'mt	Actual	Agr'mt	Actual	Agr'mt	Actual	Agr'mt	Actual	Agr'mt	Agr'mt	Agr'mt	Agr'mt	7 years	Agr'mt 7 years	Diff 7 years
CRDC Cash Contribution	350	350	350	350	350	350	350	350	1400	1400	350	350	350	2450	2450	0
Cotton Seed Distributors	300	300	300	300	300	300	300	300	1200	1200	300	300	300	2100	2100	0
Twynam Cotton	0	50	0	50	25	50	50	50	75	200	50	50	50	225	350	-125
The University of New England	0	0	0	0	0	0	100	100	100	100				100	100	0
TOTAL CASH FROM PARTICIPANTS	**650**	**700**	**650**	**700**	**675**	**700**	**800**	**800**	**2775**	**2900**	**700**	**700**	**700**	**4875**	**5000**	**-125**
NSW Government	0	0	0	0	0	0	95		95	0				95	0	95
Qld Government	646	0	618	0	591	0	841		2696	0				2696	0	2696
Other	254	0	127	0	45	0	14		440	0				440	0	440
Other (eg Interest)	128	0	48	0	48	0	44		268	0				268	0	268
External Grants	192	0	500	0	247	0	303	100	1242	100				1242	100	1142
CRDC Grants	1742	0	1707	448	1227	652	995	970	5671	2070				5671	2070	3601
OTHER CASH	**2962**	**0**	**3000**	**448**	**2158**	**652**	**2292**	**1070**	**10412**	**2170**	**0**	**0**	**0**	10412	2170	8242
CRC GRANT	**2100**	**0**	**2200**	**2200**	**2200**	**2200**	**2000**	**2000**	8500	6400	**2100**	**1800**	**1000**	**20824**	**4340**	**16484**
TOTAL CRC CASH CONTRIBUTION (T2)	**5712**	**700**	**5850**	**3348**	**5033**	**3552**	**5092**	**3870**	**10125**	**7422**	**2800**	**2500**	**1700**	**25699**	**9340**	**16359**
Cash carried forward	1336		1284		643		891									
Less Unspent Balance	388		1336		1332		1562									
TOTAL CASH EXPENDITURE (T3)	**6660**	**700**	**5798**	**3348**	**4344**	**3552**	**4421**	**3870**	**14563**	**10770**	**2800**	**2500**	**1700**	**24363**	**20570**	**3793**

ALLOCATION OF CASH EXPENDITURE BETWEEN HEADS OF EXPENDITURE

SALARIES	4495	1915	3886	2585	3045	2615	2997	2394	14413	9509	1730	1795	1232	19170	14266	4904
CAPITAL	48	0	232	0	58	0	167		505	0				505	0	505
OTHER	2120	898	1680	1022	1241	1042	1258	1083	6296	4045	899	847	512	8554	6303	2251
TOTAL EXPENDITURE	**6660**	**2813**	**5798**	**3607**	**4344**	**3657**	**4421**	**3477**	**21213**	**13554**	**2629**	**2642**	**1744**	**28228**	**20569**	**7659**

ATTACHMENT C

TABLE 3

SUMMARY OF RESOURCES APPLIED TO ACTIVITIES OF CENTRE (DOLLARS IN $'000's)

	ACTUAL 2002/03		ACTUAL 2001/02		ACTUAL 2000/01		ACTUAL 1999/00		TOTAL TO DATE								GRAND TOTAL		
	Actual	Agr'mt	Actual	Agr'mt	Actual	Agr'mt	Actual	Agr'mt	Actual	Agr'mt	2000/01 Agr'mt	2001/02 Agr'mt	2002/03 Agr'mt	2003/04 Agr'mt	2004/05 Agr'mt	2005/06 Agr'mt	Total 7 years	Agr'mt 7 years	Diff 7 years
GRAND TOTAL (IN-KIND) FROM TABLE 1 (T1)	12,213	9,053	11,139	9,119	11,129	9,161	10,120	9,154	44,601	36,487	9,161	9,119	9,053	9,043	9,033	8,983	71,660	63,546	8,114
GRAND TOTAL (CASH EXPENDITURE) FROM TABLE 2 (T3)	6,660	2,813	5,798	3,607	4,344	3,657	4,421	3,477	21,213	13,554	3,552	3,348	2,800	2,800	2,500	1,700	28,213	20,554	7,659
TOTAL RESOURCES APPLIED TO ACTIVITIES OF CENTRE (T1+T3)	18,873	11,866	16,937	12,726	15,473	12,818	14,541	12,631	65,814	50,041	12,713	12,467	11,853	11,843	11,533	10,683	99,873	84,100	15,773

ALLOCATION OF TOTAL RESOURCES APPLIED TO ACTIVITIES OF CENTRE BETWEEN HEADS OF EXPENDITURE (CASH AND IN KIND)

TOTAL SALARIES (CASH AND IN-KIND)	10,920	6,431	9,565	7,117	8,752	7,168	8,264	6,915	37,501	27,631	7,168	7,117	6,431	6,246	6,311	5,748	55,806	45,936	9,870
TOTAL CAPITAL (CASH AND IN-KIND)	48	0	232	0	58	0	167	0	505	0	0	0	0	0	0	0	505	0	505
TOTAL OTHER (CASH AND IN-KIND)	7,895	5,435	7,140	5,609	6,663	5,650	6,111	5,716	27,809	22,410	5,650	5,609	5,435	5,426	5,364	4,979	43,578	38,179	5,399

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TABLE 4

ALLOCATION OF RESOURCES BETWEEN CATEGORIES OF ACTIVITIES

	RESOURCE USAGE					
PROGRAM	$ Cash (‘000)		$ In-Kind (‘000)		Contributed Staff	Cash Funded Staff
Research	3,933.0	59.0%	9,097.0	74.5%	67.69	44.64
Education	402.2	6.0%	324.0	2.7%	1.43	0.00
External Communications	58.2	0.9%	0.0	0.0%	0.00	0.00
Technology Transfer	1,704.5	25.6%	2,792.0	22.9%	17.51	15.25
Administration	561.8	8.4%	0.0	0.0%	0.00	4.00
TOTAL	6,659.7	1.0	12,213.0	1.0	86.63	63.89
	(T3)		(T1)			

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