annual report

2000-2001

Australian Cotton Cooperative Research Centre

Cotton CRC

Established and supported under the Australian Government's Cooperative Research Centre Program

CRC

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annual report
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Research centre partners

CSIRO – Plant Industry, Entomology, Textile and Fibre Technology and Sustainable Ecosystems
Queensland Department of Primary Industries
NSW Agriculture
Agriculture Western Australia
Northern Territory Department of Primary Industry and Fisheries
The University of New England
The University of Sydney
Cotton Research & Development Corporation
Cotton Seed Distributors
Queensland Cotton
Western Agricultural Industries

Cotton CRC

CRC AUSTRALIA

Published by the Australian Cotton Cooperative Research Centre
"Myall Vale"
Wee Waa Rd
NARRABRI NSW 2390

Phone: 02 6799 1592
Fax: 02 6793 1171
Website: http://www.cotton.crc.org.au

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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 educational 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.

Executive summary

Dr Gary Fitt, CEO of the Australian Cotton CRC

Now in its second year, the Australian Cotton CRC has consolidated its activities after making the transition from the previous Cotton CRC. The Australian Cotton CRC focuses on sustainability issues for the industry, as evidenced by its support for research on new technologies and sustainable farming systems, its award winning education and extension effort, and new research into the feasibility of cotton production in northern Australia and research on cotton textiles. A number of new projects have started, and mechanisms for interaction and coordination are in place and functioning effectively.

During the year the Federal Government's innovation statement has further strengthened the CRC Scheme with prospects for ongoing funding and more CRCs being approved. This augurs well for active, productive and committed CRCs to seek renewal for a third term, and this should be a long-term plan for our CRC.

One significant change in structure is the appointment of our new independent Board Chairman, Mr Evan Cleland, who replaces John Blood, who acted as interim Board Chair for the first year. The CRC is extremely grateful to John for his contribution during our transition year, and we warmly welcome Evan to the role. Evan is the nominee of the Australian Cotton Growers Research Association (ACGRA). He brings a wealth of hands-on experience as a cottongrower at Goondiwindi, together with a commitment to supporting research and the adoption of practices that enhance sustainability of production and the environment. Evan has played a leading role in ACGRA affairs for some time and provides the Cotton CRC with additional links into the industry.

Another significant development was the decision by Twynam Cotton to withdraw from the CRC, effective in December 2000. This was a particular loss because of the outstanding support provided by the company, and previously Colly Farms Cotton, to our R&D efforts in northern Australia, particularly in the Northern Territory and Ord Region. While Twynam continues to share our vision of a sustainable cotton industry in northern Australia, the company is focussing its efforts elsewhere. Twynam's commitment is reflected in their guarantee to maintain ginning and marketing support at Kununurra for cotton produced as a result of research done in the north, and they continue to work with us in southern NSW, where we now have a coordinated effort.

We have strengthened an already comprehensive extension network with the appointment of a National Cotton Extension Coordinator, Ms Ingrid Christiansen. Ingrid has a background in the sugar industry and is now energetically pursuing her new role. Initially based at the Australian Cotton Research Institute (ACRI), Narrabri, Ingrid has responsibilities across the country to ensure our cotton extension activities are well coordinated with research activities and outcomes, well coordinated as a network, and dynamically responsive to industry and wider needs.

An environmental focus is evident in several new projects where we are seeking to broaden the funding base for cotton research and address ongoing sustainability issues associated with the industry. New initiatives in ecosystem services, salinity research and management, water use efficiency, on-farm wetlands for bioremediation and biological control options for pests and diseases are now well established and support the industry's commitment to best management practice and future development of environmental management systems. The Cotton CRC is increasing its work at the catchment scale, both directly and through partnerships with others.

Our Northern Australia Program faces a number of challenges but nonetheless is making progress. While Native Title and uncertainties about Stage 2 of the Ord River Irrigation Area are limiting work in Western Australia, our research in the Northern Territory and north Queensland is progressing with new staff in place and promising results. The northern newsletter, *Cotton Frontiers*, has proven to be a valuable conduit to diverse stakeholder groups with information about research outcomes and other activities.

The Innovative Technologies Program continues to research new techniques to manage cotton pests. A provisional patent application has been lodged to cover our attractants for *Helicoverpa*, which might be used in integrated pest management systems, and discussions with commercial partners are underway. Likewise our work on bioremediation using artificial wetlands on farm is progressing towards a pilot study in the 2001-

2002 growing season. This work has great potential to link in with future research to quantify on-farm biodiversity. Progress with new transgenic cottons expressing multiple insecticidal proteins is well advanced with commercial use possible in 2003. This work provides a direct link for innovative technology into sustainable farming systems.

Sustainable Farming Systems, our largest research program, integrates the many disciplines needed to identify optimal approaches to managing soil and water resources, the crop, and pests and how they interact with the environment to ensure the sustainability of productive cotton. This program remains the powerhouse generating many of our new postgraduate students.

Education and Technology Transfer are key elements underpinning the research success of the Cotton CRC and the long-term success of the industry. Our outstanding Cotton Production Course is a truly collaborative effort and is highly regarded as a benchmark achievement for those wanting to work in the cotton industry. Likewise, the Cotton CRC coordinates a strong national extension team, which addresses both local and national priorities.

Finally, our new Cotton Textile Program has made rapid progress in establishing research needs along the "field-to-fabric" pipeline. Following two workshops involving stakeholders from the production, ginning and spinning industries, as well as potential collaborators, the program is developing new research partnerships and seeking to optimise downstream processing and producer returns.

The Australian Cotton CRC itself is mostly about coordination. It seeks to bring together the best available research, extension and educational resources to tackle significant issues in a collaborative way. Coordination also requires close involvement with industry, a task achieved through our interaction with ACGRA, the Cotton Consultants Association, the Cotton Research and Development Corporation (CRDC) and numerous growers associations. Communication with the general community is increasingly important. We continue to participate actively in discussions about GMOs in agriculture, water use efficiency and related issues providing factual objective information to assist public understanding.

There were a number of highlights for the CRC during the year. In December 2000, the Cotton CRC won the Business and Higher Education Round Table (BHERT) Award for Collaborative Education for our outstanding Cotton Production Course, which represents collaboration between about forty researchers across all CRC participants. The Cotton course hit another milestone with the launch of the *Cotton Modules* CD ROM and website, designed to facilitate learning through multi-media components. Undergraduate modules of the cotton course are now available at three universities (University of New England, University of Sydney and University of Queensland Gatton), with great interest from students. In recognition of its support for our education products, The University of Queensland is now recognised as a supporting participant of the Cotton CRC.

Our 2001 annual review of projects in July was combined with the second year review of our science conducted by the Commonwealth. With such a widespread CRC the annual review meeting and dinner represents one of the few occasions we can draw most CRC staff together. Our annual awards for Innovation, Collaboration and Corporate Citizenship went respectively this year to: Dr Peter Gregg and Dr Alice del Socorro for their innovative research to develop an attractant for adult *Helicoverpa*; to Dr Ian Rochester, David Larsen and their team involved in collaborating to produce *NutriPAK*, a comprehensive guide to cotton nutrition; and to Mr Guy Roth, lecturer in our Cotton Production Course and a great advocate for the Cotton CRC in all his interactions with outside institutions.

Overall the Australian Cotton CRC is well placed to deliver major outcomes for Australia through a sustainable and productive cotton industry. We rely on strong commitment from core partners, an excellent team of researchers and support staff and close involvement with industry and the wider community. I look forward to playing a role in addressing the many challenges ahead.

Dr Gary P. Fitt
CHIEF EXECUTIVE OFFICER

Cotton Production Course

Students during 'hands on' lectures given by researchers of the Australian Cotton Cooperative Research Centre.

The Cotton Production Course is the pride of the Australian cotton industry and the Australian Cotton Cooperative Research Centre's education flagship. The course has surpassed its set milestones (for a full progress report, see Program 4 Technology Transfer and Education). The highlight of the course in 2000-2001 was the official launch of the *Cotton Modules* CD ROM. The cotton industry is well known for its adoption of new technology and this package is the latest in a suite of tools for distance education students. The Cotton Production Course team is committed to providing the best possible educational experience for students; this CD and website represent a major step in achieving this.

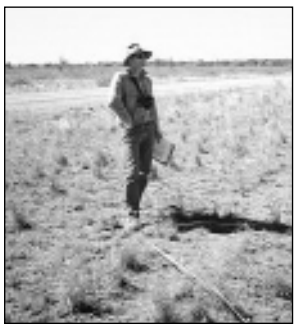
About 30 researchers from the Cotton CRC contribute to the course and it would not be possible to deliver such a comprehensive course without this collaboration. The *Cotton Modules* CD ROM contains video footage and graphics to explain course concepts. A picture says a thousand words and some things just cannot be explained in a paragraph.

The CD also contains the highly regarded course notes that, when printed out, are 30 cm high and weigh about 5 kg. The real advantage of the electronic format is that a student can search thousands of pages on specific topics. Students also receive printed notes, as most of them still prefer to study from printed materials. To protect copyright the electronic notes have been encrypted with a password system so that only officially enrolled students can have the notes. As part of this package a password protected Internet site has been established for course participants. Our students come from all cotton growing areas in Australia and this means they can interact with each other on a regular basis. They can be as far away as Western Australia, Emerald or Bourke and interact with their peers and industry experts. From a teaching perspective this means students will engage in their course more often and they can submit assignment work and quiz answers over the internet.

The *Cotton Modules* package was developed by UNE lecturers Dr Peter Lockwood, Soil Science, and Guy Roth, Cotton CRC lecturer, and was funded by the Australian Cotton Cooperative Research Centre.

Guy Roth and Gary Fitt launch the Cotton Modules *CD ROM at Narrabri in June 2001.*

Ecosystem Services in the Gwydir Valley



Associate Professor Nick Reid heads the team investigating ecosystem services in the Gwydir Catchment.

Associate Professor Nick Reid (left) and Dr Ken Hodgkinson inspect subsurface runoff on the New England Tablelands. Photo: Jodie Reseigh.

We all rely on ecosystem function for our lives and livelihoods. Where would we be, for example, if vegetation and soil biota didn't clean and filter water, if decomposers failed to convert waste material into nutrients and if insects, bats and birds didn't pollinate fruit trees? These ecological functions can be termed ecosystem services and their value is starting to be recognised.

A multidisciplinary team led by Associate Professor Nick Reid (University of New England and Australian Cotton CRC) has begun an investigation of the nature and value of ecosystem services in the Gwydir Catchment in northern NSW. Research partners include the NSW Department of Land and Water Conservation (Drs Ian Oliver and Brian Wilson), CSIRO Sustainable Ecosystems (Dr Ken Hodgkinson), UNE (Drs Nick Reid and Letitia Silberbauer), and the Centre for Agricultural and Regional Economics (David Thompson). The Australian Cotton CRC, National Heritage Trust, Gwydir Valley Irrigators Association and Department of Land and Water Conservation are funding the project.

The project began in January 2001 with parallel consultative processes with the community and scientists. The scientific consultation process is using email as a survey tool to contact 80 experts from around Australia who are participating in the consultative process. The first phase of the consultative process confirmed the importance of all 14 ecosystem services recently identified by CSIRO and the Goulburn Broken Catchment Management Board in northern Victoria, as well as many others thought relevant to the Gwydir. The experts have pointed out that one person's ecosystem service (silt-laden floodwaters improving floodplain fertility in the lower catchment) may well be another's disservice (erosion in the upper catchment).

The first phase of the community consultation process was a two-day workshop held in Moree in late June, attracting about 50 selected representatives from a wide range of resource interests and uses throughout the catchment. The community forum aimed to introduce the concept of ecosystem services to participants, to make use of the assembled experience and wisdom in identifying important ecosystem services to catchment residents and resource users, and to list and prioritise the threats to ecosystem services. By every measure the community forum was a success and has laid the foundations for a productive and collaborative research effort with the ecosystem services research team and the Gwydir community. The main areas of concern were the maintenance of soil health, maintaining and regenerating habitat and maintaining healthy waterways, river flows and groundwater levels. However, different resource use sectors had different priorities, so the final scoreboard inevitably reflected the composition of participants. People were also quick to recognise the interconnectedness of all ecosystem services.

There was broad support for and recognition of the need for an ecosystem services approach to natural resource management issues in the Gwydir catchment, especially in relation to the difficult questions of natural resource allocation among competing sectors, remuneration of private landholders for provision of ecosystem goods and services that are in the public interest (e.g. on-farm biodiversity), and evaluating the socio-economic impact of resource management targets required by statutory planning processes in NSW. Participants also raised concerns about an ecosystem services approach, including:

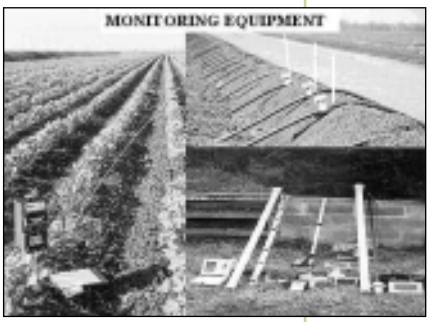
- the need for objectivity and scientific independence in conducting research into controversial ecosystem services
- the desirability of independent scrutiny and community oversight or partnerships in such research
- the technical difficulty of dealing with different biophysical scales, socio-economic values and the sheer ecological complexity and interconnectedness of ecosystems.

The project team took away three overriding messages from the community forum, which were:

- endorsement of the ecosystem services approach
- the need for continuing involvement of all resource management interests in directing and evaluating research findings
- widespread publicity for the concept to help bring the rest of the community along.

The project team is presently writing up a scoping study report and beginning research within different sub projects: the nature and value of ecosystem services in cotton production systems, and soil and vegetation health in the middle catchment. The research in these sub projects has just begun and, with continuing input from growers, the community and experts, holds great promise.

Rural Water Use Efficiency



Water is the lifeblood of the cotton industry. Using it efficiently is a key objective for sustainability. In Queensland the Australian Cotton CRC coordinates the Cotton and Grains Adoption Project within the Queensland Government's Rural Water Use Efficiency Initiative. The project is funded through Queensland Department of Natural Resources and Mines (QDNRM), is delivered by the Department of Primary Industries (DPIQ) and involves industry partnerships with Cotton Australia and Agforce.

The four-year project represents an investment of $2.8 million dollars matched by an industry investment of $3.0 million by DPIQ, the Cotton Research and Development Corporation, Cotton CRC and cotton growers. An associated Financial Incentives Scheme within the initiative is administered by Cotton Australia for the cotton and grains industries.

An implementation team of extension officers throughout Queensland works mainly through grower groups to deliver the project. Cotton CRC leadership of this project has ensured the support of its extensive research resources within the cotton industry and facilitated strong linkage with a similar initiative in NSW through the CRC Program 4 Extension Team.

The Cotton and Grains Adoption Program objectives are to increase irrigation efficiency in the cotton and grain industries by at least 10% and to have 70% of growers adopting best management practice (BMP) guidelines, which will be developed for general application to the irrigation of all crops.

The expected outcomes of the project are a productivity return of some $58 million at the farm gate combined with extensive environmental benefits associated with better use of water, reduced runoff and improved water quality in rivers and streams resulting from decreased salinity, turbidity and nutrient and pesticide loads.

The project was established in late 1999, when a coordinator and five extension officers were appointed to conduct fieldwork. A desktop stocktake of irrigation water use in the Queensland cotton and grain industries was completed during the first summer to establish benchmarks of water use efficiency in all crops and to identify opportunities for improving collaboration with grower and consultants.

Extensive fieldwork was initiated during 2000 and considerable progress has been achieved, for example:

- the project has been 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 been developed
- grower management groups have been established
- irrigation benchmark data have been collected from the cotton and grain crop demonstration sites.

The Cotton/Grains Team has monitored grower irrigation management, confirmed initial benchmarks on irrigation and water use efficiency and determined where efficiencies can be improved.

Cotton Australia and CRDC are developing a BMP irrigation management module for the cotton industry BMP guidelines. The Cotton/Grains Adoption Team is contributing to the development of this module, which will be (with some modification) suitable for the irrigated grains industry.

Over 35 Water Use Efficiency trial sites were established last year – in cotton, peanuts, sorghum, wheat, maize, navy beans and faba beans. Irrigation systems included furrow, SDI (subsurface drip irrigation), centre pivots, lateral moves, side roll and handshift sprinklers.

The SDI trials in heavy and light soils at Dalby, St George, Theodore and Emerald produced excellent results with increased yield, reduced water use and improved use of in-crop rainfall. There were also encouraging results from furrow irrigation trials and benchmarking activities with some farmers achieving comparable yields and water use efficiency levels to the SDI trials. Given the results of top irrigators, the target ten per cent improvement in water use efficiency to 1.25 bales/ML is achievable for many growers.

National Extension Coordinator

Ms Ingrid Christiansen was appointed to the National Cotton Extension Coordinator (NCEC) position in December 2000 and started work 19 February 2001 at ACRI Narrabri, where she will be located for the first fifteen months of the project before relocating to DPIQ offices in Toowoomba.

Ingrid Christiansen, National Extension Coordinator.

The major activities of the NCEC are to:

- coordinate the National Cotton Extension Team by developing, initiating, leading, evaluating and supervising the National Development Extension Program, which has been negotiated with industry
- establish mechanisms for interaction with local, regional, State, national and international clients and other stakeholder groups to determine development extension needs of the cotton industry, prioritise major issues and develop a strategic plan
- develop and support the adoption and implementation of effective delivery systems by industry development extension officers by collaborating with them to establish participatory learning systems in regional extension programs
- train and maintain the knowledge of extension staff in modern adult education principles and processes
- develop a plan and, in collaboration with the Integrated Pest Management Training Coordinator, provide extension training for cotton industry research and extension personnel and encourage their participation in new development extension processes, particularly formal adult education processes
- establish and maintain linkages between the extension program, industry best management practice programs, industry traineeships and formal tertiary education providers
- develop a strong understanding of IPM systems, particularly for insect and resistance management, in both conventional and transgenic technology
- coordinate the production of extension material including local newsletters and research review articles.

The NCEC works with the CRC Extension Management Committee to develop and act on national priorities in extension. This committee consists of: Dallas Gibb, NSW Agriculture; Gus Shaw, NSW Agriculture; Bruce Pyke, CRDC; Geoff McIntyre, QDPI; Adam Kay, CRDC; and Bruce Finney, ACGRA.

The Cotton CRC Extension Team includes 14 extension staff located across the cotton growing regions of Queensland and NSW. They work closely with local growers and consultants to develop their extension activities. It is critical that their work plans are coordinated and meet the national issues facing the industry. This team has been divided into six focus teams, which develop specific extension activities and material for use nationally. Members of the CRC Extension Management Committee have been allocated to specific teams with designated team leaders, as shown on page 11.

An Evaluation and Benchmarking Team has also been established to examine the rate of technology adoption and changing attitudes towards the adoption of IPM, resistance management and overall changes to the farming system.

CRC Extension Management Committee supervisors and team leaders.

National Focus	Team Supervisor	Team Leader
Insect Management	Dallas Gibb	James Quinn
Environment/BMP	Bruce Pyke	Peter Hughes
Farming Systems	Gus Shaw	Mark Hickman
Weed Management	Gus Shaw	David Kelly
Disease Management	Geoff McIntyre	Greg Salmond
Water Management	Geoff McIntyre	Phil Goyne

Area wide management (AWM) is seen as a high priority and tools are being developed to help the extension team support these groups. Sharing ideas between regions and using economic benchmarking of IPM are valuable in enhancing the interest in AWM.

The promotion of research outcomes needs to be consistent and well planned to ensure that new technology is adopted throughout the industry. The NCEC will ensure that national extension programs are developed and implemented. In collaboration with the Extension Coordinating Committee, Ingrid will provide overall coordination of the industry extension program and provide extension support to research and extension officers throughout the industry.

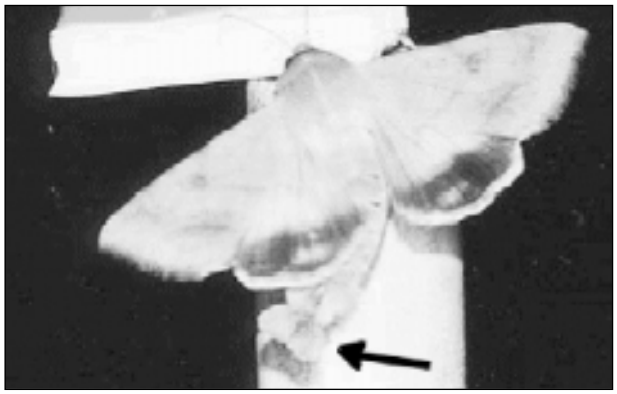
Annie Spora, Trainee Industry Development Officer, at the Moree Cotton Trade Show

Semiochemical Approaches to Control of *Helicoverpa* Spp.

Helicoverpa moths are the major pests of cotton production. An innovative way to manage them is to modify their behaviour by using semiochemicals (behaviour-modifying chemicals) such as attractants or repellents. The Australian Cotton CRC has been researching this approach for some time.

This project continues the work of an earlier one in the CRC for Sustainable Cotton Production. We have screened a total of 40 plants, thirty six single chemicals and 28 chemical blends in an olfactometer, which tests their attractiveness to *H. armigera* females. We have also conducted a total of 21 field trapping trials testing thirty two types of attractant lures. Of the blends tested in the olfactometer, 20 were found to be significantly attractive.

We also analysed the pheromones produced by male moths to determine whether they may contain useful close-range attractants for female moths. An electric grid trap was designed to improve trap catches in the field. This type of trap caught about 5 times more than the AgriSense® canister traps using pheromone lures.



A male H. armigera *moth approaching a pheromone lure displays its hair pencils (arrowed). Male pheromones released during this display may influence female behaviour, and are being investigated as potential components in female-attracting lures.*

A disposable field wind tunnel used for studies on attractants for female H. armigera *moths.*

An innovative field wind tunnel has been used to test various types of formulations and to characterise moth responses around lures using night-vision glasses. On nights when the weather was suitable, many moths were observed approaching the lure. Characteristic plume-following and hovering flight behaviour indicated they were responding to the volatiles.

Many moths repeatedly approached the lures, hovered, then backed off. Behavioural observations suggest that there are specific close-range stimuli (chemical or visual), which are missing from the way we present lures in field wind tunnels, and probably traps. Further work is clearly needed.

Laboratory and field feeding experiments were conducted to determine if moths would ingest a formulation that contained our attractive volatiles, a feeding stimulant and a toxicant, and to see if ingesting the formulation would kill them.

Using this approach we were able to achieve kill rates from 70 to 100%.

The project has now culminated in a provisional patent application entitled 'Attractants for moths" (Patent No. PR4797) lodged with the Australian Patent Office in May 2001. Expressions of interest in supporting this work have been received from a number of companies and we expect commercial partnerships to be established in the future. A research partnership has been established with Performance Feeds Ltd, a stockfeed producer in the Darling Downs, following preliminary observations by company and CRC personnel of significant numbers of noctuid moths being attracted to one of their products. This provides another avenue for research and possible development.

Overall, our work in semiochemicals promises to provide new biologically based tools to help with integrated management of Australia's key cotton pests.

Participants

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

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

Organisational structure

GOVERNING BOARD

An independent chairman appointed by the Australian Cotton Growers' Research Association (ACGRA) chairs the Governing Board. The board is responsible for controlling the policy, practices and overall operation of the Cotton CRC. Its functions and powers include: the strategic direction of the Centre; developing performance indicators, programs and activities of the CRC; approving annual budgets and commercial arrangements; negotiating funding for the CRC; and appointing and reviewing the performance of the Chief Executive Officer. The board meets four times a year and consists of a majority of non research providers.

Australian Cotton Cooperative Research Centre's Governing Board, September 2001. (l to r) Bob Galmes, John Grellman, Dr Jim Cullen (alternate for Dr Jim Peacock), Evan Cleland, Helen Scott-Orr, Prof. Peter Flood, Bridget Jackson, David Hamilton, Dr Gary Fitt and Di Bentley (centre). Absent are Roberta Brazil, Bruce Brown, Dr Graeme Robertson and Professor Keith Entwistle.


Evan Cleland


Bridget Jackson


John Grellman


Bruce Brown


Bob Galmes


Roberta Brazil


Dr Gary Fitt

NON RESEARCH PROVIDERS

Chairman	Mr Evan Cleland
Cotton Research and Development Corporation	Ms Bridget Jackson
Cotton Seed Distributors	Mr John Grellman
Queensland Cotton/Western Agricultural Industries	Mr. Bruce Brown
Independent Member	Mr Bob Galmes
Independent Member	Mrs Roberta Brazil
CEO (100% Centre funded)	Dr Gary Fitt

RESEARCH PROVIDERS

CSIRO	Dr Jim Peacock
NSW Agriculture	Ms Helen Scott-Orr
Department of Primary Industries Queensland	Mr David Hamilton
Agriculture Western Australia/Northern Territory	
Department of Primary Industry and Fisheries	Dr Graeme Robertson
University New England/University of Sydney	Prof. Keith Entwistle


Dr Jim Peacock


Helen Scott-Orr


David Hamilton


Dr Graeme Robertson


Professor Keith Entwistle

MANAGEMENT COMMITTEE

The Management Committee is chaired by the CEO and helps the Governing Board manage operations of the CRC. It meets four times a year and its main responsibility is to help meet the objectives of the centre through implementing policies as determined by the Governing Board. This comprises: assessing and recommending research projects to the Governing Board; overseeing progress of research projects and achievement of performance indicators; managing resource allocation; education and training; information services; publication of research outcomes; technology transfer; and commercialisation.

The CRC Management Committee and colleagues from Cotton Australia. Back row (l to r): Associate Prof. Peter Gregg, Dr Dave Murray, Dallas Gibb, Geoff Strickland. Middle row (l to r): Ralph Leutton (Cotton Australia), Dr Col Martin, Dr Gary Fitt, Dr Peter Cookson, Dr Stephen Allen, Associate Prof. Alex McBratney, Bruce Pyke. Front row (l to r): Rob Cairns (Cotton Australia), Nicky Schick, Dr Lewis Wilson, Dr Michael Bange.

All research providers are represented on the Management Committee, and with the exception of Program Five, each program is managed by joint program leaders. Members are as follows:

Dr Gary Fitt (Chair)	CEO	Australian Cotton CRC
Mr Geoff Strickland	Program One Leader	Agriculture WA
Dr Michael Bange	Program One Leader	CSIRO Plant Industry
Associate Prof. Peter Gregg	Program Two Leader	UNE
Dr Stephen Allen	Program Two Leader	Cotton Seed Distributors
Dr Lewis Wilson	Program Three Leader	CSIRO Plant Industry
Prof. Alex McBratney	Program Three Leader	University of Sydney
Mr Dallas Gibb	Program Four Leader	NSW Agriculture
Mr Geoff McIntyre	Program Four Leader	Queensland Department Primary Industries
Dr Peter Cookson	Program Five Leader	CSIRO Textile & Fibre Technology
Mr Bruce Pyke		Cotton R & D Corporation
Dr Colin Martin		NT Dept Primary Industry & Fisheries

NORTHERN COMMITTEE

A Northern Committee comprising the Chief Executive Officer, program leaders of Program One, and research and industry partners concerned with feasability of cotton in new regions has been established. This committee advises the Management Committee on research priorities for Program One; ensures research expertise from programs Two, Three and Five flow into the new regions; and acts as a focus for interaction with northern communities and interest groups.

The Cotton CRC has also appointed Stephen Yeates as the Northern Liaison Officer based in Darwin. He provides regular reports to, and takes direction from, the Management Committee and the Northern Committee. A specific northern Australia communications strategy has been prepared.

The Northern Committee is committed to meet once per year, but in the first year of the Cotton CRC it met five times to establish the program's research priorities and management. Its members are as follows:

Dr Gary Fitt	Australian Cotton CRC
Mr Geoff Strickland (Chair)	Agriculture WA
Dr Michael Bange	CSIRO Plant Industry
Dr Ian Titmarsh	Queensland Department Primary Industries
Dr Colin Martin	NT Dept Primary Industry & Fisheries
Mr Barry Wilson	Queensland Cotton
Mr Ivan McLeod	Western Agricultural Industries
Mr Adam Kay	Cotton Seed Distributors
Mr Stephen Yeates	CSIRO Plant Industry

ADVISORY COMMITTEE

The Advisory Committee provides feedback on the quality of the science undertaken by the Cotton CRC; comments on its relevance to the cotton industry; assesses progress against key objectives; identifies any perceived research gaps or suggests future research directions or both; provides feedback on possible additional linkages the CRC could be using to further its objectives; and provides advice and information about existing and emerging industry and community concerns.

Members of this committee, listed below, have been drawn from the Australian Cotton Growers Research Association, consultants within the cotton industry, research organisations, other agricultural industries, and the broader community.

Mr Bruce Finney (Chair)	Australian Cotton Growers Research Association
Mr James O'Conner	Cotton Consultants Australia
Dr Chris Moran	CSIRO Land & Water
Dr Don Sands	CSIRO Entomology
Dr Graeme Hammer	Queensland Department Primary Industries, APSRU
Mr Geoff Coats	Queensland Department Primary Industries, Rural Extension Centre
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 established discipline-specific working parties to provide direction to and feedback from components of industry and the broader community.

ADMINISTRATION

Administration Team (l to r): Kym Orman, Lynda George and Nicky Schick.

ADMINISTRATION TEAM MEMBERS

Executive Officer/Business Manager	Maxine O'Brien CSIRO (until March 2001) Kym Orman, CSIRO (from May 2001)
Research Liaison Officer	Nicky Schick, CSIRO
Administration Assistant	Jane Maynard, CSIRO (until June 2001) Lynda George, CSIRO (from July 2001)

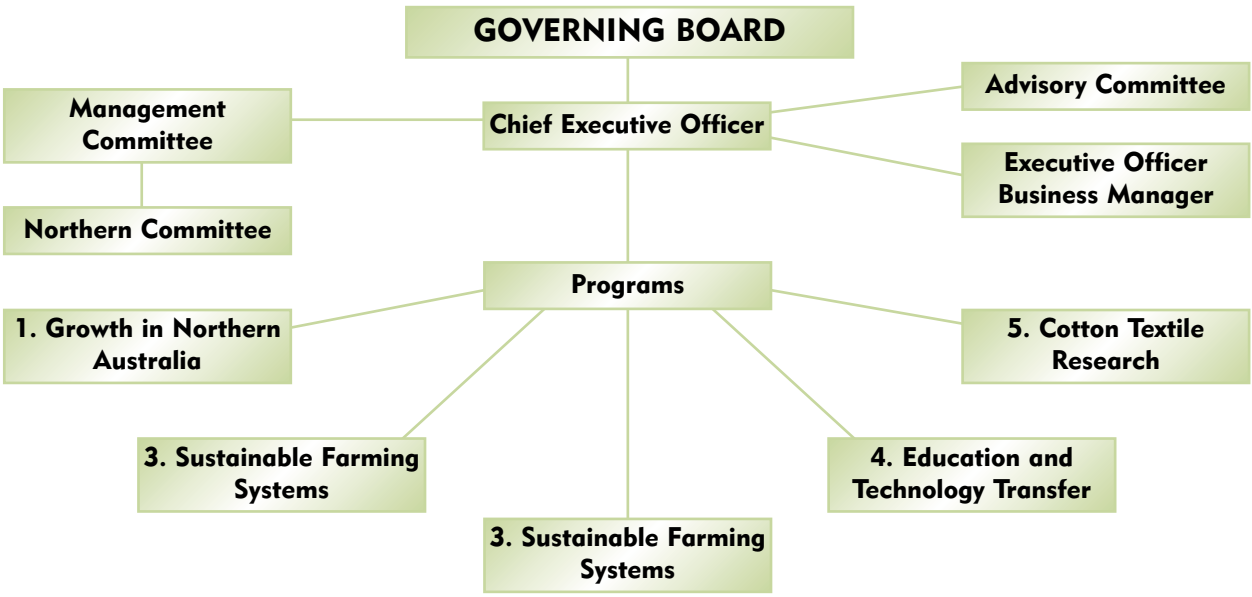


Figure 1. Structure of the Australian Cotton CRC.

Cooperative linkages

Success in any CRC rests on its capacity to engender a culture of collaboration, which draws on the full capabilities of each participant, and to use this internal strength to maximise linkages with other organisations. Wherever possible we encourage projects that involve collaboration with more than one participant and seek to develop a team approach in our research and technology transfer programs.

To achieve this we have developed a series of discipline groups to cover all facets of cotton research (e.g. IPM, weeds, diseases, farming systems, water and soils). The groups meet regularly and meetings are coordinated by program leaders and a research liaison officer, and involve research providers, extension staff, growers, consultants and other industry groups. Discipline coordinators operate through the Management Committee to finalise priorities for future work. Our annual review meeting also provides an opportunity for both science and social interaction among all members of the CRC.

Our strongest interactions are with the cotton industry itself through the Australian Cotton Growers Research Association, whose representative chairs the CRC board and which provides participants in all the CRC's discipline groups. Our commercial participants further strengthen linkages into specific parts of the industry. This is particularly evident in the Northern Australia Program, where interactions are facilitated through a Northern Committee with representatives from all researcher providers and commercial participants.

Two components of our Extension and Education Program provide additional foundations for linkage across the CRC and into industry and the wider community. The Cotton CRC's Technology Resource Centre continues to effectively coordinate 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).

In the past year we have had regular links with a range of community, commercial and R&D funding organisations and have started a process of explicitly seeking to broaden the sources of support for cotton research and development by building new external collaborations. The following list highlights the diversity of the Cotton CRC's collaborative activities:

- The Cotton CRC participated in a public forum at Richmond in north Queensland to discuss opportunities for future agricultural enterprises in the area. Cotton is clearly one option attracting much attention. We have cooperated closely with Richmond Shire Council and the Southern Gulf Catchment Committee to provide objective information to assist with public debate in the region as well as conducting our research program.

- We continue to play a key role in developing management strategies for transgenic cottons (insect and herbicide tolerant) through collaborations with the Weeds CRC, Australian universities (UNE, Queensland, and Melbourne), US universities (Arkansas, Mississippi State, North Carolina, Arizona), USDA-ARS researchers in southern USA, and with regulatory agencies in Australia (GMAC, IOGTR) and the USA (EPA). This work also brings links to Monsanto Australia.
- We have initiated a major cooperative effort to develop an integrated research program on water balance and deep drainage in the northern Murray-Darling Basin. After a workshop of thirty research groups and stakeholders in October 2000, we organised a meeting (October 2000) of State and federal funding agencies to achieve in-principle support for research into the area. The proposed program will involve research in natural, dryland and irrigated ecosystems with the Cotton CRC responsible for managing the irrigated component. Participants will include CRC participants from QDNR/QDPI, NSW Agriculture, CSIRO, University of Sydney and direct involvement with CSIRO Land and Water, groundwater researchers in DLWC and UNSW and the CRC for Catchment Hydrology. The project is now in a scoping phase with financial support from Murray-Darling Basin Commission (MDBC), Land & Water Australia (L&WA), CRDC and the Cotton CRC.
- An increasing focus on research at the interface of agricultural production and the natural environment. The CRC board includes an independent member representing environmental interests, while the MDBC and Amateur Fisherman's Association Northern Territory are represented on our Advisory Committee.
- Our research into environmental issues such as salinity and potential impacts of irrigation on riverine environments provides cooperative links to irrigator associations in the McIntyre, Gwydir, Namoi and Macquarie regions.
- Our new project on Ecosystem Services Supporting Cotton Production in the Gwydir Valley has grown through collaboration with DLWC and the CSIRO-Myer Foundation National Program on Ecosystems Services to encompass an economic and ecological assessment of natural ecosystem services across the entire Gwydir Region. This has lead to close collaboration between the cotton industry, other industries, urban communities and catchment management groups. The Gwydir Catchment Management Board is now intimately involved through a seat on the project steering committee.
- Catchment Management boards in NSW and similar structures in Queensland represent a structured opportunity to cooperate with a cross-section of producer and community representatives in cotton producing regions. To initiate dialogue with these and other groups responsible for catchment management issues we organised a highly successful Catchment Management Forum in Narrabri in May 2001. This was attended by representatives from 25 Catchment Management boards, as well as from community groups and government agencies, and established a number of common themes for future development and specific commitments by several groups for follow up action.
- We have sought to strengthen links with other CRCs relevant to our research portfolio. These links include:
  - a joint postgraduate student project with the CRC for Tropical Plant Pathology to develop diagnostic tools to help with managing *Fusarium* wilt, a significant threat to cotton production
  - two joint projects with the CRC for Weed Management Systems; one involving a postgraduate student to research management strategies and monitoring requirements for herbicide tolerant cottons (e.g. Roundup Ready cotton); and the other to research weed management systems for dryland cropping systems in northern NSW and southern Queensland
  - holding discussions with the CRC for Freshwater Ecology to explore joint opportunities for research on biodiversity in rivers and on-farm waters associated with cotton.

- Links to other research groups include research on cotton bunchy top conducted through collaborative links with CSIRO, Adelaide and with NSW Agriculture, Gosford.
- With irrigation and water use efficiency having a high profile we are successfully managing the Cotton and Grains Program of the Queensland Rural Water Use Efficiency (RWUE) Initiative. This brings funding of $3 million over four years and close collaboration with the Queensland Department of Natural Resources and Mines, and with RWUE teams in the dairy, sugar and horticulture sectors in Queensland.
- The Cotton CRC extension network plays a key role in facilitating the cooperation needed to develop area-wide management approaches now being successfully implemented throughout the cotton industry.
- Our education program has now broadened its linkages to a range of educational institutions, with the undergraduate unit in Cotton Production now available at The University of New England, University of Sydney, University of Queensland Gatton, University of Western Sydney and Orange Agricultural College. Great interest has been shown in the course at The University of Queensland and University of Sydney. As a result we now recognise The University of Queensland as a supporting participant of the Cotton CRC.
- The CRC's extension team has very strong linkages with farming system extension programs in NSW Agriculture and the Department of Primary Industries Queensland, and has cooperated with Cotton Australia to spread the message of BMP, now being widely adopted across the industry.
- Our new program in Cotton Textile Research has developed close alliances with a number of Australia's leading cotton processors, who are now supporting partners of the Cotton CRC. These include Rocklea and Sheridan, and chemical companies such as Ciba and Clariant.
- Building on the Fibre Plus Workshops held in 2000, we have established explicit links between our cotton textile researcher group at Geelong and the National Centre for Engineering in Agriculture (NCEA) at The University of Southern Queensland, Toowoomba. This collaboration covers the "field-to-fabric" pipeline, with research capability spanning critical points along the processing path.

INTERNATIONAL LINKAGES

The CEO, Dr Gary Fitt, is an executive member of an International Working Party established by the International Organisation of Biological Control (IOBC). The Working Party is focussed on the role of transgenic plants in integrated pest management and seeks to establish protocols to ensure GM plants provide benefits in many parts of the world. This provides the CRC with links to research groups in Europe, USA, Asia and Africa.

Many other international linkages are maintained through the personal associations of individual scientists. We facilitate this through a research exchange program, which supports a number of international exchanges each year. During 2000-2001 we supported visits by:

- Mr Martin Dillon (CSIRO) to the XXI International Congress of Entomology, Brazil and a study visit to the USA related to area wide management, trap cropping, resistance and modelling
- Dr Jonathon Holloway (NSW Agriculture) to the XXI International Congress of Entomology, Brazil
- Dr Melina Miles to the USA to study area wide management of insect pests in southern USA
- Dr Jackie Cai to attend the 2000 AATCC International Conference and Exhibition in the USA
- Dr Tom Lei sponsored Dr Mitsutoshi Kitao, a research scientist, from Sappora Japan to Australia.

Program One

Growth in Northern Australia

INTRODUCTION

There are opportunities to expand cotton production to new regions where soils are suitable and water availability is assured. Significant surface water resources are available from the Ord and Fitzroy rivers (WA); Katherine, Roper and Daly rivers (NT); and the Flinders, Gilbert and Einasleigh rivers (Qld). As well, major underground water reserves have been identified near Broome and Katherine. Previous attempts to grow cotton in the Ord River Irrigation Area during the 1970s ended in disaster because of uncontrollable insect populations. Today, with greater understanding of pest ecology, a change to winter production systems, and the availability of new pest control strategies based on transgenic plants and other novel biological controls, we have an opportunity to reevaluate cotton production in northern areas. This does not mean simply transferring production practices for eastern Australia into northern systems. The tropical north has a vastly different environment and growing conditions, and specific research is needed to fully evaluate potential and tailor production systems.

The regions proposed for investigation in Western Australia (Broome and Kununurra); the Northern Territory (Katherine and Douglas/Daly areas) and north Queensland (Flinders River and others) provide significant opportunities to expand the industry. The potential area for new cotton, 200,000 ha, would produce a further one and a half million bales with an export value of $750 million. 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.

AIMS AND MILESTONES

Program 1 aims 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
- develop solutions to specific regional environmental problems before commercial activity.

To pursue these objectives, seven milestones have been established for the first two years of CRC operations.

Milestones - years 1 and 2:

1. A Northern Committee convened to define specific research and development needs.
2. A report produced documenting the status of current and past cropping research activities relevant to cotton production in northern Australia.
3. Appropriate research staff and industry liaison officers appointed.
4. IPM studies in the Ord Region of northwestern Australia continued in collaboration with farmers.
5. Baseline studies of key pests, weeds and diseases commenced with experiments and surveys.
6. Agronomic, entomological and IPM experiments commenced in all northern regions.
7. Major environmental issues defined for each region by 2001 and benchmarks for a sustainable production system established.

HIGHLIGHTS AND ACHIEVEMENTS AGAINST MILESTONES

Significant progress towards all milestones has been achieved and, most importantly, Stephen Yeates has now completed the northern scoping study (milestone 2). The docu-

Cotton from northern research must often be transported long distances to ginning facilities.

ment will be widely available as a Cotton CRC publication after final reviewing and printing, and will be an important resource for targeting future research projects.

Human resources in northern Australia (milestones 1 and 3) were greatly boosted during the year with the appointments of Brian Duggan (CSIRO, Kununurra - agronomy), Andrew Ward (NTDPIF, Katherine - pest management), Terry Woodger (DPIQ, Richmond - pest management) and Andrew Davies (UQ, Kununurra - *Trichogramma* PhD). Agronomist positions at Katherine and Richmond will be filled soon and will provide an important critical mass in the northern regions. The CRC has been fortunate to recruit high calibre staff to these important positions to complement existing staff in these areas.

CRC projects that have been approved to start include (milestones 4, 5 and 6):

1. Project Number 1.1.0 AC: Northern Australia cotton disease survey
2. Project Number 1.1.1 AC: Viable and environmentally responsible cotton production systems for northern Australia: scoping studies and research liaison/coordination officer (Darwin)
3. Project Number 1.2 AC: Cover crops and rotations for sustainable cotton cropping systems on light textured soils in NW Australia (Broome)
4. Project Number 1.2.1AC: Integrated pest management systems for sustainable transgenic cotton production in the west Kimberley (Broome)
5. Project Number 1.3.1 AC: Insect dynamics of the cotton ecosystem in the Northern Territory (Katherine)
6. Project Number 1.4.1 AC: Pest management for transgenic cotton in Far North Queensland
7. Project Number 1.4.2 AC: Agronomy and farming systems for cotton production in northern Queensland (Richmond).

Other significant highlights are as follows:

- A workshop involving all cotton CRC researchers involved in activities relating to northern Australia was held in Darwin in December. In addition to setting northern priorities, the workshop highlighted the two-way flow of benefits between north and south. Some examples included testing *CottonLOGIC* on Palm Pilot, modelling temperature effects on crop growth and plant compensation to insect damage studies.
- A meeting convened to discuss salinity issues at Richmond and identify strategies for progressing them.
- Farmer participation in IPM trials at Kununurra has increased to the maximum permissible area of 450 ha.

- Richmond trials have expanded to an area of 360 ha, including agronomic and pest dynamics studies.
- The Northern Territory Government has issued a "Strategic Plan for Cotton Research and Development in the Northern Territory until 31 December 2005", which in essence formalises support for cotton research there. Irrigated trials on 30 ha at the Katherine Research Station are underway.
- Results of research recording cotton crop development in northern Australia have been collated for analysis with the specific aim to improve the cotton growth simulation model.
- Northern disease survey completed.
- The Cotton CRC has raised the awareness of the need for careful disease quarantine to protect the north against serious pathogens such as *Fusarium*. Legislation is proposed.
- Meetings with environmental groups in Darwin and Richmond have been held to clarify their concerns about prospects for cotton growing.
- Community awareness of CRC activities has been enhanced with the publication of the first two editions of the *Northern Frontiers* newsletter.
- The CRC sponsored a visit by Professor Williams, an expert on Mychorrizae, to Katherine Research Station where he provided input to Dr Stan Bellgard's research on mycorhizzal associations of cotton in the Northern Territory.

LINKAGES AND COLLABORATION

Linkages between CRC research providers and the commercial partners are very strong. Cotton Seed Distributors and Queensland Cotton provide important logistical and direct support of CRC activities in several northern locations. In addition, the CRDC funds projects of direct relevance to the northern areas and there are linkages with several projects funded in the south. Important CRDC projects include:

- AWA2C Defining an integrated pest management (IPM) system for INGARD cotton in northwestern Australia
- UQ28C Ecology of *Trichogramma* egg parasites in the Ord River Irrigation Area and their role in cotton IPM
- CSP95C Development of agronomic management options for dry season cotton production in northwestern Australia.

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

- CSE90C Ecological studies of *Helicoverpa* populations related to the successful implementation of IPM systems based on Bt transgenic cottons
- DAN139C Pesticide resistance in cotton aphid and twospotted mite
- DAN118C Resistance management in Australian cotton: conventional insecticides and transgenic cottons
- CSP96C Breeding improved cotton varieties
- CSP124C Predicting and enhancing cotton compensation following pest damage
- CSP125C Continued development and field evaluation of micro-computer cotton management packages
- CSP140C The impact of temperature extremes on cotton performance
- CSIRO Chief Executive Award "Adapting *NutriLOGIC* to Northern Australian Cotton Crops" - Greg Roberts
- Ecological and environmental aspects of the release of transgenic cotton in northern Australia
- The Ord-Bonaparte Project. The Cotton CRC had input into the planning process of the project and has representation on the project's management committee. It is expected that the Cotton CRC will conduct research under this project in the area of on-farm research of water use efficiency and to quantify the impacts of agricultural practices on Ord River water quality and quantity.

Project Number: 1.1.1 AC

Viable and Environmentally Responsible Cotton Production Systems for Northern Australia: Scoping Studies and Research Liaison/Coordination Officer

AIMS AND MILESTONES

The aim of this project is to 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:

- facilitating actions following the publishing of a scoping report detailing the status of current and past cropping research activities, emphasising production and industry development issues relevant to cotton production in northern Australia
- providing scientific support to the Chief Executive Officer and program leaders and to provide some supervision of projects located in northern Australia.

Milestones are as follows:

1. Publish a scoping study and distribute to core partners of the Cotton CRC, then start the implementation process.
2. Maintain effective communication with all appropriate research industry bodies, core partners of the CRC, relevant committees, and CRC management on matters relating to commercial development of cotton production in northern Australia.
3. Provide regular feedback and reports to the Chief Executive Officer, Program 1 leaders, Northern and Management committees.
4. Provide project supervision under the direction of the Chief Executive Officer and Program 1 leaders.
5. Where necessary initiate new research projects.

STAFF

Mr Stephen Yeates, CSIRO Plant Industry, Darwin, NT (appointed 2 December 1999)

PROGRESS

Milestone 1. Publish a scoping study and distribute to core partners of the Cotton CRC, then start implementation process.

The scoping study draft has been completed and distributed to the core CRC partners who are Northern Committee members for review and comments. The study is currently being reviewed by CSIRO before it is published as a Technical Report, after which it will be distributed widely.

Some salient results of the scoping study are as follows:

- The study region, defined as the area north of the line from 21°S on the east coast to 20°S on the west coast, is immense and represents about 30% of the land area of Australia. The potential land and water resources of the region are large. The Gulf of Carpentaria and the Timor Sea drainage divisions alone account for 43% of Australia's annual surface water run-off compared with 6% for the Murray-Darling Basin. Groundwater resources are also significant.
- The scoping study reviewed issues relating to cotton development in 21 catchments and regions across northern Australia. These catchments and regions were categorised in terms of their irrigation development status and whether cotton was being researched (Table I).

Table I: Irrigable areas reviewed in the scoping study and their development status.

Development status	Catchment or region	Town(s)	Drainage area
1. Existing (non cotton) irrigated cropping and/or potential for expansion	Ord River Irrigation Area*	Kununurra,	Timor Sea
	Bowen/lower Burdekin	Bowen, Ayr	Coral Sea
	Atherton, Mareeba–Dimbulah	Mareeba	Coral Sea
	Lakeland Downs	Laura, Mareeba	Coral Sea
2. New areas under development or evaluation	La Grange Sub-basin*	Broome	Indian Ocean
	Daly Basin*	Katherine	Timor Sea
	Flinders River*	Richmond	Gulf
3. Undeveloped for large-scale irrigated cropping	Fitzroy River	Fitzroy Crossing, Derby	Indian Ocean
	Lennard River	Derby	Indian Ocean
	Baines/Victoria River	Timber Creek, Kununurra	Timor Sea
	Sturt Plain	Larrimah, Daly Waters	Timor Sea, Gulf
	Adelaide River, Marrakai	Plain Darwin, Adelaide River	Timor Sea
	Barkly Tableland	Tennant Creek, Brunette Downs	Gulf Roper
	River/north-western Gulf	Roper Bar, Borroloola	Gulf
	Gilbert/Einasleigh	Einasleigh, Georgetown	Gulf
	Mitchell/Lynd	Kowanyama, Palmerville	Gulf
	Cloncurry/Corella/Leichhardt/ Gregory	Cloncurry	Gulf
	Upper Herbert	Mt Garnet, Ravenshoe	Coral Sea
	Bowen/Broken	Collinsville	Coral Sea
	Cape York (eg. Kendall, Holroyd, Edward, Archer, Coleman, Watson Rivers)	Coen, Weipa, Pormpuraaw, Aurukun	Gulf/Coral Sea
	Upper Burdekin	Charters Towers	Coral Sea

* = site of cotton R&D in 2000.

- Lessons from past R&D aimed at large scale development in northern Australia were reviewed. An important finding was, "The need for a systems approach with goals understood and accepted by all organisations. Research alone can not produce commercial success, rather it must be integrated with commercial development, and a large-scale trial phase is essential".
- Except for the Ord River, the Katherine-Daly Basin and the established cropping areas in north Queensland (Table I), soil surveying and land resource assessment are required at a larger scale for irrigation development. Moreover, with the exception of established irrigation areas in north Queensland and the Ord River (under review), water licensing arrangements have not been determined.
- With the exception of some of the established cropping areas in north Queensland, most of the arable soils are similar, i.e. red and yellow earths and poorly drained cracking clays, all with moderate to low inherent fertility. This implies similar issues for crop nutrition, soil surface management and irrigation distribution systems. Areas where inherent salinity occurs can be broadly identified from information currently available.
- Climatic analyses suggested that cotton could be grown in all 21 regions reviewed in this study, provided that water and arable soil are available. However, these analyses found several limitations in the tools used to assess the climatic potential of northern Australia for cotton.
- There is a potential for a mixture of winter and summer cropping close by, particularly in north Queensland, which may create an opportunity for migration of *Helicoverpa armigera* between growing seasons, thus increasing the risk of resistance to insecticides and the Bt proteins.

Researchers at work in Northern Australia

As land and water resource development is required in many areas of northern Australia, the basic research required to evaluate new production areas extends beyond the main skills base of the Australia Cotton CRC (Table 2).

Table 2. Basic research required to evaluate a new irrigation area with cotton as a candidate crop.

1. Geohydrological surveys and studies
   These will determine potential salinity problems, water table effects and identify appropriate irrigation and agronomic practices.
2. Detailed soils surveys
   Currently most regions are at a scale not greater than 1:250,000 and irrigation development would require at least 1:100,000 with reference areas at 1:25,000 in locations with potential for irrigated cropping.
3. Production system research
   Integrated crop research is required to develop a management system that is economically sustainable and has minimal environmental impacts.
4. Ecological studies into pest and disease dynamics and effects on flora and fauna.
5. Water licensing process and associated studies.
6. Infrastructure studies, e.g. location of gin, transport links and containerisation needs.
7. Whole scheme economic analysis to put in a State and national context. This should include an assessment of community value.

Project Number: 1.3.1 AC

Insect Dynamics of the Cotton Ecosystem in the Northern Territory

AIMS AND MILESTONES

The primary aim of this project is to benchmark the ecology of the key pest and beneficial insects that are likely to impact on a future cotton industry in the Katherine area before assessing preliminary integrated pest management systems.

The key milestones to be achieved in the first year of the project are to:

1. Monitor key lepidopteran pests weekly using pheromone traps at 8 sites.
2. Assess resistance levels to conventional insecticides during the season.
3. Determine the baseline susceptibilities of *Helicoverpa armigera* and *Helicoverpa punctigera* to Bt.
4. Collaborate with CSIRO in a strontium mark-recapture study of regional *Helicoverpa* spp. population dynamics.
5. Monitor *Trichogramma* activity and identify local species.
6. Rear and identify beneficial insect species and rank their status in the Northern Territory.

STAFF

Dr Andrew Ward, Northern Territory Department of Primary Industries and Fisheries (NTDPIF) Research Entomologist, Katherine
Ms Megan Hoskins, NTDPIF, Technical Officer, Katherine
Ms Keera Shrimp, NTDPIF, Technical Assistant, Katherine

PROGRESS

A number of preliminary trials were established in 2000 by Megan Hoskins to begin to assess the population dynamics of key pests in cotton at Katherine. This work focused mainly on cotton that was sprayed and unsprayed as well as watered using both permanent trickle and overhead irrigation systems. The results of this work suggested that there were no differences in either the biodiversity or abundance of insects in sprayed crops grown using overhead or permanent trickle irrigation. However, as expected, there were differences in the abundance of insects between the sprayed and unsprayed areas with fewer insects in the sprayed areas. Major pests included brown mirids, green vegetable bugs, redbanded shield bugs and *Helicoverpa* spp.

With the appointment of Andrew Ward at Katherine in March 2001, the research program has been expanded to address the agreed milestones of the project. Research started with the planting of this year's cotton crop at Katherine in April. The research can be broadly broken into three key areas. These are:

- studies examining the population dynamics of both pest and beneficial insects in cotton at Katherine
- assessment of insect resistance to both Bt and conventional insecticides
- preliminary assessment of components of potential IPM systems for cotton grown in the Northern Territory.

Population dynamics (milestones 1, 4, 5 and 6)

The following studies are being undertaken to examine the population dynamics of cotton pest and beneficial insects:

- Twice weekly monitoring of crops grown using both permanent trickle tape and overhead irrigation to assess the abundance and biodiversity of pest and beneficial insects in each system. Included in the overhead irrigation area are small blocks of Bollgard II™ cotton and unsprayed conventional cotton.

- Weekly monitoring of the seasonal abundance of Lepidopterous pests at eight sites including both bush and established cropping areas using pheromone traps. Species being examined are *Helicoverpa armigera* (8), *H. punctigera* (8), *Spodoptera litura* (5), *Pectinophora gossypiella* (5), and *Spodoptera exigua* (2).
- Two-weekly monitoring of egg and larval parasitism in *Helicoverpa* and how this changes over time. *Trichogramma* spp. will be identified by Andrew Davies (University of Queensland).
- Two-weekly monitoring of *Helicoverpa* populations using Lepton test kits to identify how the species mix changes throughout the season.
- Regular monitoring of the broader environment to determine the sources of both pest and beneficial insects outside the cotton ecosystem.

On the advice of Geoff Strickland (CRC Program Leader) it has been decided to defer the strontium mark recapture studies until after similar studies at Broome are completed.

Resistance monitoring (milestones 2 and 3)

- Baseline susceptibility of *H. armigera* and *H. punctigera* to Bt at Katherine is being assessed in collaboration with Dr Ho Dang (NSW Agriculture, Narrabri). *Helicoverpa* spp. resistance to other insecticides is being assessed in collaboration with Dr Robin Gunning (NSW Agriculture, Tamworth).

Preliminary components of potential IPM systems for Northern Territory cotton are being assessed as follows:

- Assessment of the suitability of various trap crops for both sucking insects (green vegetable bugs and brown mirids) and *Helicoverpa*. Crops being assessed are niger, chickpea, sesame, lablab, kenaf and pigeon pea.
- Preliminary assessment of the feasibility of using Confidor™ (imidacloprid) applied through permanent trickle tape for the control of sucking insects (green vegetable bugs and brown mirids).
- Preliminary assessment of the feasibility of using Temik™ (aldicarb) applied both at planting and as a side dressing at first square to control early season sucking insects.

When combined this work will provide a basis for the development of a sustainable cotton industry with minimal reliance on insecticides in the Northern Territory.

Monitoring weather conditions in northern Australia

Project Number: 1.4.1

Pest Management for Transgenic Cottons in Far North Queensland

AIMS

The aims of this project are to:

1. Conduct local research to assess the insect pest problems associated with grower-scale trials of transgenic cotton varieties in Richmond.
2. Evaluate the effectiveness of transgenic cottons against the major pests *Helicoverpa armigera* and *H. punctigera* under the agronomic conditions experienced in Richmond.
3. Determine local field parameters for optimising:
   - the dilution of resistance in insect species of concern
   - the management strategy developed for *Helicoverpa* on transgenic cotton
   - a trap cropping program for *Helicoverpa* control.
4. Identify options and opportunities specific to Richmond conditions for Integrated Pest Management (IPM) of insect pests on transgenic cotton; including the potential for trap cropping.

STAFF

Dr Ian Titmarsh, QDPI, Program Leader, Farming Systems Institute, Emerald
Dr Richard Sequeira, QDPI, Senior Research Scientist, Farming Systems Institute, Emerald
Mr Terry Woodger, QDPI, Technical Officer (Entomology) based in Richmond

PROGRESS

The first large-scale evaluation of INGARD cotton in the Richmond environment is nearing completion and preliminary analyses of the results indicate a highly favourable outcome in terms of product efficacy and pest management. An abundance of beneficial insects was recorded on most crops throughout the evaluation. The inescapable conclusion is that beneficial insects played a significant part in keeping *Helicoverpa* pressure at manageable levels.

There appears to be considerable potential for strip cropping as a management tool for mirids. The Emerald (CQ) RMS for INGARD cotton appears to be suitable in its entirety for implementation in the Richmond environment. Pigeon pea stands out as the most suitable *Helicoverpa* refuge option. The use of 'soft' insecticidal options in conjunction with strip cropping and exploitation of the abundance of beneficial insects observed augurs well for an efficient and low-impact pest management system for INGARD in Far North Queensland.

Cotton research in northern Australia has a strong emphasis on IPM.

Project Number: 1.4.2

Agronomy and Farming Systems for Cotton Production in Northern Queensland

AIM AND MILESTONES

The aim of this project is to conduct agronomic research to guide the development and implementation of a sustainable production system for cotton in northern and Far North Queensland. It focuses on the issues of:

- growth, development and yield of transgenic Bt cotton under regimes of minimal pesticide use
- summer and winter production for increased return on capital
- sustainable practices that have minimal impact on the environment.

Year 1 milestones were as follows:

1. Report on performance and constraints to Year 2000 research crop at Richmond.
2. Have results of Year 1 experimentation on yield/insect control in INGARD cotton.
3. Identify and complete a preliminary evaluation of potential cotton production areas in northern Queensland.
4. Establish relationships with researchers involved in transgenic cotton production and modelling.

STAFF

Dr Ian Titmarsh,QDPI, Program Leader, Farming Systems Institute, Emerald
Research Scientist (Cotton Agronomy), (in process of appointment)
Technical Officer (Cotton Agronomy), (in process of appointment)

Progress

Through its Farming Systems Institute (FSI), DPIQ leads the Cotton CRC research in northern Queensland and is the proponent on GMAC and National Registration Authority approvals to grow up to 500 ha of INGARD cotton for research at Richmond. The 2001 research trial has a total planted area of 397.5 irrigated hectares. Planting was completed on 12 January 2001. The area comprises six varieties of transgenic INGARD cotton (361 ha) and a research trial encompassing refugia and trap crops of unsprayed conventional and INGARD cotton, corn, sorghum, lablab, pigeon pea and niger (36.5 ha). Some cotton was replanted in the first week of February.

Because of unavoidable delays in recruitment and selection the research agronomist and technical officer were not in place for this season. Both positions will be filled in time for planning and implementation of next season's work.

Not having a full complement of project staff has limited the scope of agronomic research planned for 2000-01. Basic data relating to weather, crop performance and site characterisation, particularly soil parameters, have been collected, and these results will contribute positively in planning for work to be conducted in the next two seasons.

Program Two

Innovative Technologies

INTRODUCTION

Successful commercial cotton production relies on a number of chemical inputs. While progress has been made in adoption of transgenic plants, integrated pest management and best management practice, there remains an imperative to seek alternative management tools that 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.

There have been nine Cotton CRC funded projects and 15 CRDC projects addressing the aims and objectives of the Innovative Technologies Program. Five postgraduate students are associated with the CRC projects.

AIM AND OBJECTIVES

The aim of the program is to research and develop innovative technologies that provide an improved range of options for environmentally acceptable crop management and bioremediation.

Its objectives are to:

- rigorously evaluate the efficacy and environmental impacts of new transgenic plants
- develop and evaluate the use of attractants and repellents for *Helicoverpa* spp.
- identify and evaluate effective biocontrol agents for soilborne pathogens of cotton
- investigate the use of 'biofumigation' and 'systemic induced resistance' for improving the efficacy of disease control strategies
- 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
- investigate bioremediation techniques for pesticide contamination on cotton farms.

The use of new technologies emerging from this program will be developed in Program 3, in the context of sustainable farming systems, and flow into northern research projects in Program 1.

HIGHLIGHTS AND ACHIEVEMENTS

Evaluation and Management of Transgenic Cotton

This was the first season when combinations of the new Cry 2Ab gene were available. Results using a standard 5-day neonate bioassay demonstrated the high and consistent efficacy of Cry IAc/Cry 2Ab combinations and of Cry 2Ab alone.

Studies of INGARD varieties were continued at a number of locations. Field counts of larvae and laboratory bioassays confirmed previous findings of declining efficacy during crop development. The occurrence of differences in efficacy between tissues taken from different nodes on the plant was also confirmed.

Cotton tipworm, rough bollworm and cotton looper are susceptible to both Cry IAc and Cry 2A proteins. Tobacco looper had previously been shown to be relatively insensitive to Cry IAc. Further laboratory assays confirmed this observation and demonstrated that tobacco looper was highly susceptible to Cry 2Ab.

Previously experiments had shown that efficacy of Bt plants was influenced by temperature. In a second series of experiments Bt plants grown in a warm temperature regime (22 to 34°C) had 2 to 3 times higher efficacy than those grown in a cooler regime (14 to 26°C), confirming earlier results. Results from an experiment in which plants were exposed to changes in temperature regime were inconclusive with some cohorts showing increased efficacy and others decreased. Overall the work suggests the influence of temperature is complex.

Bruce Tuff (left) and assistant Lance Hayward, both from Busy Bee Narrabri, setting up laser moth monitoring equipment

Isolation of Genes Controlling Fibre Development in Cotton

The Glabra 1 and Glabra 2 genes from *Arabidopsis* encode transcription factors that are known to be involved in initiating single-celled hairs on stems and leaves. A Glabra 2 homologue has been isolated from cotton. This gene is expressed in fibres throughout their development and also in other tissues including stems, leaves, roots and flowers. A gene construct that should specifically suppress the activity of the cotton Glabra 2 gene has been made and introduced into cotton. The transgenic cotton plants will be assessed for changes in fibre development and fibre properties and the functional role of Glabra 2 in cotton will be determined.

Semiochemical Approaches to Controlling* Helicoverpa *spp.

Two new, potentially more attractive blends of plant volatile chemicals have been identified using the olfactometer. These two blends performed better than the previously developed, standard, three-component blend. Techniques to study the behaviour of moths around lures have been developed and used to investigate potential close-range stimuli, which may be important in determining whether moths will contact or ingest a lure. Two types of ingestible formulations containing plant volatiles, a feeding stimulant and a toxicant have been developed and tested in field wind tunnels. A provisional patent application, "Attractants for moths", which covers the principles involved in formulating the most attractive blends, has been lodged with the Australian Patent Office. Expressions of interest in the project have been received from a number of semiochemical and insecticide companies.

Mating Behaviour in* Helicoverpa armigera*: Influence of Host Plants

A study of female response to host-plant volatiles revealed that the presence of host plants does affect female behaviour. Generally moths spend more time calling in the presence of host-plant volatiles. Two- and three-day-old females (the age at which females of this species normally mate) were found to produce more pheromone when in the presence of host plant volatiles.

However, field studies using captive females and light and pheromone traps found no evidence that the type of host crop influenced mating success. There was nothing to suggest that any particular crop should be planted as a refuge for its effects on mating behaviour. Other factors are viewed as more important in selecting refuge crops (e.g. number of moths produced) or selecting trap crops (e.g. attractiveness for oviposition).

On-farm Production and Dissemination of Baculovirus for Pest* Helicoverpa *Control in Cotton – A Feasibility Study

Recent studies have shown that large quantities of a naturally occurring nuclear polyhedrosis virus can be produced on farm by strategically applying a commercial viral insecticide to host *Helicoverpa* populations. This project is investigating the feasibility of applying a technique new to cotton that uses populations of beneficials to spread this virus into cotton for improved *Helicoverpa* control.

Although feeding studies showed that two species of earwig had good potential as virus disseminators (in favouring virus infected prey and being capable of consuming several infected larvae in rapid succession), the pattern of virus defecation revealed that the virus is expelled far too quickly for these insects to be at all effective as virus disseminators in the field.

Other predator species, when combined, may be capable of transporting enough virus to have an impact on pest *Helicoverpa* in cotton. Trials are being planned for next season to investigate this question to determine the merit in continuing this research into a third year.

Molecular Diagnosis of* Fusarium *Wilt of Cotton in Australia

A collection of Australian and overseas isolates of the pathogen which causes *Fusarium* wilt (*Fov*) has been established. This collection is being extensively characterised using a number of different molecular techniques.

DNA sequence information that is unique to the two Australian strains of *Fov* has been identified and primers that specifically amplify the Australian strains have been developed. The PCR reaction conditions have been optimised for each of the sets of primers. At present the PCR tests for each strain are performed in separate reactions but the intention is to combine the two sets of primers into a multiplex reaction that will detect both strains in a single reaction.

The current focus of the laboratory work is to optimise PCR amplification directly from infested soil, infected plant material and contaminated seed.

Molecular Marker Systems for Breeding Cotton Cultivars with Enhanced Resistance to* Verticillium *Wilt Disease

Two AFLP (Amplified Fragment Length Polymorphism) markers linked to a gene encoding resistance to *Verticillium* wilt in cotton were identified. These markers (marker 8 and marker 63) lie on either side of the *Verticillium* wilt resistance gene. The technique is being optimised to reduce the complexity and time taken to obtain PCR-amplifiable DNA and to achieve a higher success rate of PCR amplification. Cotton species and breeding lines with known responses to infection with *Verticillium* wilt will be tested to determine the effectiveness of these markers for phenotype prediction.

Forty-seven putative defence response genes that are up regulated during *Verticillium* wilt infection have been partially characterised. Full sequence characterisation has been completed on six PR (Pathogenesis Related) protein genes. The gene activity profiles of PR protein genes are being analysed to understand their role in defence response mechanisms operating in wilt-tolerant cotton plants. Genes selected as indicators of the defence response mechanism could be employed as 'RNA' markers to confirm the presence of the genes encoding enhanced wilt tolerance.

Development of Molecular Marker Technologies in Cotton

The aim of this project was to apply DNA marker techniques to cotton and to determine if they could be used to enhance traditional breeding programs. The study sought DNA markers linked to three model traits that were chosen because they were easily assessed and thought to be controlled by single genes. The traits were okra leaf, brown lint and bacterial blight resistance.

No markers were found linked to either the okra leaf or brown lint genes. This was due to the extremely low level of polymorphism detected between the two parents used in the mapping cross. The lack of polymorphism could be due to the low genetic diversity of cultivated cotton or to the variation within parental varieties that obscures the variation between the parental varieties. A wider (interspecific) mapping cross was used to search for DNA markers linked to the bacterial blight resistance gene. One novel DNA marker was detected linked to the blight resistance gene – but fairly distant from it. More closely linked DNA markers are being sought.

Bioremediation Enzyme for Endosulfan Sulphate

Endosulfan sulphate is the toxic, water-soluble, breakdown product of endosulfan that persists in soil and water for several months. It is a significant contaminant of downstream water and the major component of the endosulfan residues found in contaminated beef.

A bacterium that can degrade endosulfan sulphate to a non-toxic compound has been successfully isolated. This bacterium is now being investigated as a source of a gene-enzyme system capable of detoxifying endosulfan sulphate.

ASSOCIATED CRDC FUNDED PROJECTS THAT CONTRIBUTE TO THE PROGRAM 2 OBJECTIVES

Evaluation of Transgenics

CSE 74C: Efficacy of Bt cotton plants and causes of variation in performance - Dr Joanne Daly

Semiochemicals

UNE 33C: Studies of slow-release formulations for semiochemicals in cotton pest management - David Britton

Novel genes

ANU 6C: Testing the tomato I-2 gene for its ability to confer *Fusarium* resistance in cotton - David Jones

ANU 4C: Cloning genes to manipulate cotton fibre cellulose production for improved fibre traits - Joanne Burn

CSP 104C: Evaluation of disease tolerance of transgenic cotton lines containing genes for putative antifungal proteins - Dr Helen McFadden

CSE 82C: Characterisation of a potential new insecticidal transgene - Erica Crone

Biofumigation, Biocontrol and Induced Resistance

DAN 121C: Disease of Cotton (VI) – Dr David Nehl

DAN 122C: Black root rot and slow early season growth of cotton – Dr David Nehl

DAN 123C: Controlling cotton seedling diseases and vascular wilts with micro-organisms – Dr Subbu Putcha

UQ 29C: Biology, ecology and utilisation of the Damsel bug as a predator in cotton – Mark Wade

DAQ 95C: In field development of novel options for *Helicoverpa* control in Central Queensland – Paul Grundy

CSD PATH: Controlling *Fusarium* wilt of cotton – Dr Stephen Allen, Mr Greg McNamara

Bioremediation

US 39C: Remediation of pesticides on cotton farms – Angus Crossan

Diagnostic kits

CRDC 123C: Bt gene test kit

LINKAGES

Important linkages within and outside the Cotton CRC are listed below for the key projects in Program 2.

Evaluation and Management of Transgenic Cotton

Monsanto, Cotton Seed Distributors Ltd, CRC for Weed Management Systems (Professor Rick Roush), University of Melbourne (Dr David Heckel), Queensland Department of Primary Industries (Dr Richard Sequeira, Dr David Murray)

Semiochemical Approaches to Control* Helicoverpa *spp.

Shanghai Institute of Entomology (Professor Jia-Wei Du), University of Queensland (Dr Craig Hull), University of Hamburg (Dr F. Ibarra), Lund University (Professor Christer Lofstedt), IPM Technologies Inc, USA ,Biocontrol Ltd, Performance Feeds Ltd

On-farm Production and Dissemination of Baculovirus for Pest* Helicoverpa *Control in Cotton – A Feasibility Study

CSIRO Narrabri, Martin Dillon

Molecular Diagnosis of* Fusarium *Wilt of Cotton in Australia

Queensland Department of Primary Industries (Dr Joe Kochman, Dr Natalie Moore), CRC for Tropical Plant Protection (Dr Suzy Bentley), Cotton Seed Distributors Ltd (Dr Stephen Allen), SARDI (Dr Kathy Ophel-Keller, Dr Alan Mackay)

Molecular Marker Systems for Breeding Cotton Cultivars with Enhanced Resistance to* Verticillium *Wilt and other Diseases
CSIRO Plant Industry, Narrabri (Dr Greg Constable, Peter Reid), Cotton Seed Distributors Ltd (Dr Stephen Allen), University of Sydney (Dr Bruce Lyon)

Isolation of Genes Controlling Fibre Development in Cotton
Department of Genetics, Adelaide University (Dr Sharon Orford and Associate Professor Jeremy Timms)

Bioremediation Enzyme for Endosulfan Sulphate
Orica Ltd and HRDC (Dr Irene Horne), Melbourne University (Dr Helen Billman-Jacobe), University of Nebraska (Professor Anthony Zera)

Project Number: 2.1.1 AC

Evaluation and Management of Transgenic Cotton

AIMS AND MILESTONES

The aims and milestones for this project were as follows:

- Commence field evaluation of new lines of Bt transformed varieties expressing Cry IAc and Cry 2Ab proteins using replicated small plots at several locations to quantify seasonal patterns of efficacy of field grown plants against *Helicoverpa* species.
- Quantify the concentration of Bt proteins, nitrogen, tannins and sugars in plant samples collected from different plant parts, stages of development and varieties expressing combinations of Cry IAc and Cry 2Ab to establish relationships to field patterns of efficacy.
- Conduct efficacy screening of transgenic cotton lines to provide breeders with additional information in the selection of lines for progression to improved varieties
- Complete studies of the efficacy of Cry 2Ab cottons against minor lepidopteran pests, specifically cotton tipworm, cotton leaf perforator, *Spodoptera* and loopers.
- Quantify the impact of Bt plants on growth and adult fitness of *Helicoverpa* spp.
- Test variations in efficacy in response to stress between Bt cotton varieties, constructs and promoters. Investigate the effect of stress factors individually on different Bt varieties. Factors to be tested include different temperature regimes and insect damage (Canberra).
- Complete a series of publications on the transgenic cotton research during the past 6 years.

STAFF

Dr G. P. Fitt, CSIRO Entomology, Narrabri
Ms C.L. Mares, CSIRO Entomology, Narrabri
Dr G. Baker, CSIRO Entomology, Canberra
Dr R. Mahon, CSIRO Entomology, Canberra
Ms K. Olsen, CSIRO Entomology, Canberra

PROGRESS

This was the first season when combinations of the new Cry 2Ab gene were available. Field experiments were completed with four varieties (Sicala 40, Sicala V3, Sicot 289, Siokra V16), expressing both Cry IAc and Cry 2Ab genes (previously referred to as Cry

X) from *Bacillus thuringiensis*. One variety, Sicala V2, was available with only Cry 2Ab, while a wide range of varieties expressing Cry IAc was included.

Laboratory bioassays demonstrated the high and consistent efficacy of Cry IAc/Cry 2Ab combinations and of Cry 2Ab alone (Figure 2). We have shown previously that such efficacy in a bioassay would result in no survival under field conditions. The small numbers of larvae that survived to five days never averaged 0.5 mg in weight compared to 1.25 to 2.0 mg for those on INGARD plants and 3.75 mg for those on control varieties. There was no significant difference in efficacy or larval weight between different varieties with the two Bt genes, in contrast to our previous experience with INGARD varieties.

We also continued studies of INGARD varieties at a number of locations. Field counts of larvae and laboratory bioassays confirmed previous findings of declining efficacy during the crop development (Figure 3). We have also confirmed differences in efficacy of tissues taken from different nodes on the plant. Efficacy increases down the plant, with leaves at node 8 having twice the efficacy of those from node 3.

Much effort is now directed to quantifying concentrations of Cry IAc in INGARD varieties using ELISA. An earlier technique has been further adapted to provide high and consistent protein extraction and determination of Bt using antibodies produced by Dr Danny Llewellyn (CSIRO Plant Industry). A number of samples from previous seasons have been assayed. These include tissues from a range INGARD varieties sampled in earlier experiments samples from different tissues within plants and samples from commercial crops. Bt concentration has been shown to correlate well with efficacy revealed from bioassays.

A number of new experiments have been conducted. One experiment took advantage of floods in the Namoi Valley in November 2000. A crop of INGARD cotton (Nucotn 37), submerged by floodwater, was studied to identify any changes in efficacy or Bt levels. Figure 4 shows there was little difference in Bt concentration between plants which had been totally immersed in water for two days, those which had been flooded but not immersed (moderate) and those which had not been flooded at all (dry). Clearly we do not yet understand the influence of stresses on the expression of Bt transgenes. Bt levels in squares were about 50% of those present in leaves.

Research has shown that Cotton tipworm, rough bollworm (*Earias huegeli*) and cotton looper (*Anomis flava*) are susceptible to both Cry IAc and Cry 2A proteins. Tobacco looper (*Chrysodeixis argentifera*) had previously been shown to be relatively insensitive to Cry IAc. Further laboratory assays have confirmed this but demonstrated that tobacco looper is highly susceptible to Cry 2Ab. Further work is needed with *Spodoptera* spp. and *Earias* to confirm the range of activity of the Cry 2Ab protein.

Finally we have conducted a series of experiments in controlled environments seeking to understand the factors that lead to variable efficacy of Bt varieties in the field. All work involved use of a standardised leaf disk bioassay technique, which had been thoroughly validated previously.

Figure 2. Bioassay survival of neonate *H. armigera* larvae on node 4 leaves from control varieties and those expressing Cry IAc and Cry 2Ab genes, alone or in combination. Plant grown at PBI, Narrabri, 2000-2001.

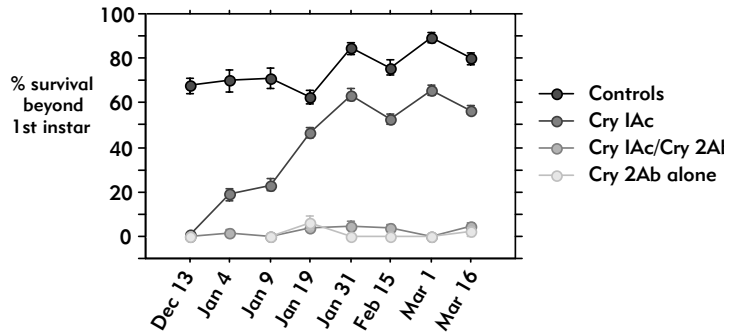


Figure 3. Seasonal bioassay efficacy of control varieties and all commercial INGARD varieties (Field 18, ACRI, 2000-2001)

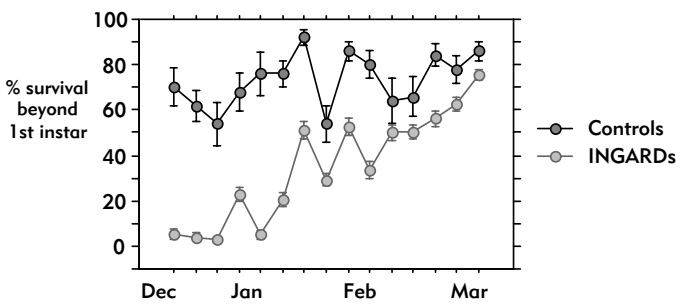
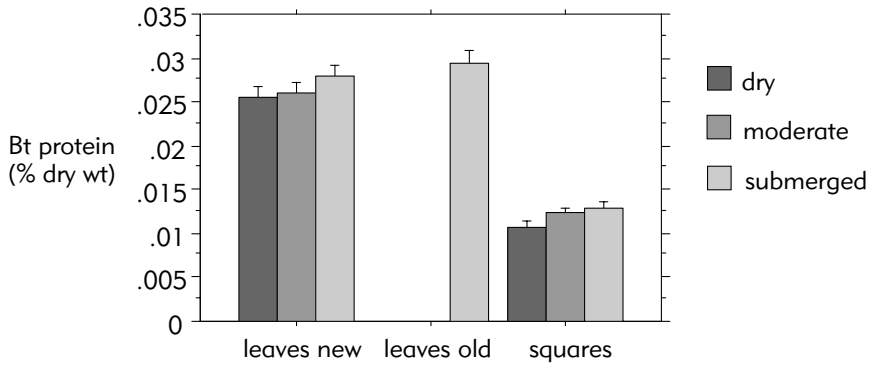


Figure 4. Concentration of Bt protein (expressed as % dry wt) in tissues of INGARD plants exposed to varying levels of inundation (November 2000). "Dry" plants were not affected by floodwater, "moderate" plants sat in floodwater for a period, but were not covered, while "submerged" plants were almost totally immersed in floodwater for at least 2 days.



The research has further demonstrated an effect of temperature on the efficacy of Bt cotton. Plants grown in a warm temperature regime (22 to 34°C) had 2 to 3 times higher efficacy than those grown in a cooler regime (14 to 26°C), confirming earlier results. An experiment in which plants were exposed to changes in temperature regime produced inconclusive results with some cohorts showing increased efficacy and others decreased. Overall the work suggests the influence of temperature is complex.

Other experiments have examined the effect of insect damage on the efficacy of Bt cotton at pre-squaring and flowering growth stages. Laboratory bioassays of plants previously damaged by *Helicoverpa* larvae showed a threefold increase in efficacy of four Bt varieties compared to controls. Similar increases in efficacy following feeding damage were also seen in fruiting plants. Such changes have yet to be confirmed in field grown plants.

Conventional cotton plants also responded to insect damage. Larvae reared on undamaged leaves for seven days were 4 to 20 times heavier than those reared on damaged leaves, and mortality was also lower. Thus the response of Bt varieties following damage is likely a combination of changes to the expression of Bt (or presentation of the toxin) and changes in secondary plant compounds.

Project Number: 3.3.1

Isolation of Genes Controlling Fibre Development in Cotton

AIMS AND MILESTONES

The aims and milestones of this project are to:

- Augment our knowledge of cotton fibre biology at the molecular level by isolating and characterising genes that have a regulatory role in the initiation and development of cotton fibres. The cotton homologues of two *Arabidopsis* genes, Glabra 1 and Glabra 2, are initial targets. Other genes encoding transcription factors will also be identified.
- Assess the role of these genes by developing transgenic plants that have reduced levels of expression of the gene products.

STAFF

Ms Lexie Press, CSIRO Plant Industry, Canberra
Dr Danny Llewellyn, CSIRO Plant Industry, Canberra
Dr Liz Dennis, CSIRO Plant Industry, Canberra

PROGRESS

This project has tried to isolate genes from cotton that are involved in controlling production of cotton fibre with the long term aim that they might be used to engineer the quality or yield of fibres in transgenic plants. We have initially targeted two types of regulatory or master control genes similar to genes known in other species to control leaf and root hairs which are similar structures to the seed hairs of cotton that have developed into cotton fibres. One type of gene is represented by Glabra 1, which is a MYB type regulatory gene found in *Arabidopsis*. This gene is critical for leaf hair development.

We have isolated and characterised a set of cotton genes encoding MYB class transcription factors that are expressed in cotton fibres. These genes were isolated from a cDNA library constructed from cotton ovules collected at the early stages of fibre initiation. Ten of the MYB genes are previously unknown cotton genes but they have similarity to MYB genes isolated from other plants, most of unknown function. A cotton Glabra 1 homologue was not amongst those isolated from cotton, despite extensive attempts. It may be that Glabra 1 is specific to the brassica family, as we were able to use similar approaches to isolate Glabra 1 homologue from two other brassicas, canola and the brassica weed, hoary cress. All our attempts to isolate a Glabra 1 equivalent from other plants were unsuccessful, however, one gene has sequence features in common with *Arabidopsis* Glabra 1 and *Arabidopsis* GA MYB thought to have a function in the gibberellin hormone controlled growth of leaf hairs. The GA MYB gene has been shown in barley and *Arabidopsis*, to be a regulator of genes controlled by the hormone gibberellin. Gibberellin is a necessary hormone in cotton fibre initiation and elongation. Therefore, the cotton Glabra 1 GA 'hybrid' gene is a candidate for further analysis. Direct functional analysis of the gene, will be assessed by generating transgenic cotton plants with reduced levels of the gene product, and this work will be ongoing.

The second type of regulatory gene, cloned in collaboration with University of Adelaide researcher, Dr Sharon Orford, was the cotton Glabra 2 gene. This gene controls later stages of leaf hair growth in *Arabidopsis* and might also have a role in cotton fibre growth. A Glabra 2 genomic clone was isolated at CSIRO and a construct, which suppresses the level of the Glabra 2 gene product has been engineered and introduced into cotton. Mature transgenic plants harbouring the construct will be assessed for changes in fibre development and fibre properties to confirm the function of this gene in fibre development.

An increased understanding of the role the Glabra 2 gene and MYB genes have in fibre biology will assist in the development of transgenic cotton with altered fibre traits.

Project Number: 3.2.5

Development of Molecular Marker Techniques in Cotton

AIMS AND MILESTONES

The aims and milestones of this project are to:

- apply molecular marker techniques to cotton
- determine the level of polymorphism within *Gossypium hirsutum* cultivars and between *G. hirsutum* and *G. barbadense* cultivars
- search for markers linked to the okra leaf, brown lint, and bacterial blight resistance genes
- use previously mapped markers to identify chromosomal locations of the okra leaf and bacterial blight resistance genes
- assess feasibility of application of molecular marker techniques to cotton breeding programs.

STAFF

Mr Dainis Rungis, PhD student, University of Sydney, Canberra
Dr Danny Llewellyn, CSIRO Plant Industry, Canberra
Dr Liz Dennis, CSIRO Plant Industry, Canberra
Dr Bruce Lyon, University of Sydney, Sydney

PROGRESS

Molecular marker (or DNA marker) techniques allow the genes controlling agronomically important traits to be mapped. This involves detecting DNA markers that are linked to or "flag" the location of a particular gene. Once these genes are mapped, the DNA markers can be used to infer the presence or absence of a particular gene without the need for testing for the trait controlled by that gene. This can speed up the breeding process, as agronomic traits do not have to be measured directly, but can be identified at the seedling stage. For example, if a DNA marker was found that flags a disease resistance gene, the presence of that gene could be detected as soon as DNA can be extracted from a plant, and without exposing the plant to the causal pathogen.

The aim of this project was to apply DNA marker techniques to cotton and to determine if they could be used to enhance the traditional breeding programs. The success of a marker project depends on the ability to detect differences (or polymorphisms) at the DNA level between the two parents of a cross. The more polymorphism between the two parents, the more likely it is to detect a DNA marker linked to a particular gene. In this study, DNA markers linked to three model traits were sought. The traits were okra leaf, brown lint and bacterial blight resistance. These traits were chosen as they were easily scored, and were thought to be controlled by single genes.

No markers were found linked to either the okra leaf or the brown lint gene. This was due to the extremely low level of polymorphism detected between the two parents used in the mapping cross. The lack of polymorphism between the two parents could be due to the low genetic diversity of cultivated cotton, but could also be attributed to the variation found *within* parental varieties, which obscures the variation *between* the parental varieties. A wider mapping cross was used to search for DNA markers linked to the bacterial blight resistance gene. The level of polymorphism detected between the two parental varieties was correspondingly higher. One novel DNA marker was detected linked to the bacterial blight resistance gene. This marker was fairly distant from the bacterial blight resistance gene, but the screening of more DNA markers may identify a marker closer to the resistance gene.

DNA markers can be of use to enhance cotton breeding programs, but the traits targeted for DNA marker assisted selection will have to be carefully chosen, and the construction of mapping populations controlled to maximise the chance of detecting DNA markers linked to the targeted trait.

Project Number: 2.2.1 AC

On-Farm Production and Dissemination of Baculovirus for Pest *Helicoverpa* Control in Cotton – a Feasibility Study

AIM AND MILESTONES

The aim of this project is to contribute to the integrated management of pest *Helicoverpa* species in cotton through research into the feasibility of a novel technique for the on-farm production and dissemination of viral insecticides.

Year 1 milestones are to conduct:

1. Laboratory studies to assess the feasibility of managing populations of arthropod predators as mobile disseminators of NPV in cotton.
2. Field trials to assess late season pigeon pea traps crops for use as on-farm *Helicoverpa* baculovirus production systems.

STAFF

Dr Andy Richards, Research Scientist, CSIRO Entomology, Canberra
Ms Janelle Scown, Technical Officer CSIRO Entomology, Canberra

PROGRESS

This project is investigating the feasibility of applying a technique new to cotton that uses late season trap crops designed to concentrate populations of pests to magnify production of a naturally occurring viral insecticide and then employ populations of beneficial insects to spread this virus into cotton for improved management of *Helicoverpa*.

Field and laboratory experiments were used to:

- assess candidate species for use as virus disseminators
- evaluate late season pigeon pea trap crops for virus production.

For the first of these two milestones, we evaluated two species of earwig that are abundant in cotton, highly mobile and fairly resilient to chemical spray drift to determine their food preference and feeding rate, and the pattern of virus defecation from their gut.

Although feeding studies showed that these species had good potential as virus disseminators (they favour virus infected prey and are capable of consuming several infected larvae in rapid succession), the pattern of virus defecation revealed that virus is expelled far too quickly after ingestion for these insects to be at all effective as disseminator virus to other parts of a farm. By themselves, other predator species in cotton such as ladybird beetles, spiders, red and blue beetles, sucking bugs and lacewings, are unlikely to have the necessary attributes of abundance, mobility and foraging behaviours for virus dissemination but it is possible that combined these species may be capable of transporting enough virus to have an impact on pest *Helicoverpa* in cotton. Trials are being planned for next season to investigate this question to determine the merit of continuing this research into a third year.

Project Number: 2.2.13 AC

Mating Behaviour in *Helicoverpa armigera*: Influence of Host Plants

AIMS

The aims of this project are to:

- determine whether mating success in *Helicoverpa armigera* is influenced by the surrounding host plants
- determine the underlying mechanisms involved if host plants are found to influence mating success
- train a postgraduate student as a future research entomologist.

STAFF

Dr Peter Gregg, Associate Professor, University of New England
Olivia Kvedaras, Postgraduate student, University of New England
Dr Chris Moore, Principal Chemist, Queensland Department of Primary Industries
Dr Alice Del Socorro, Research Officer, University of New England
Mr D. Alter, Professional Officer, University of New England

PROGRESS

It is well documented in the literature that reproductive success in animals depends on maturation rate, fecundity and mating success. Larval nutrition affects maturation rate and fecundity, and adult nutrition (nectar) affects longevity and fecundity. In *H. armigera* it is not known if host plants affect mating behaviour and therefore mating success.

Mating is energetically expensive and risky, so investment in mating could be related to how close suitable larval hosts are. Previous work has shown increased pheromone production in the presence of host plants (McNeil 1989, Raina 1992) in other species, but does this apply to a highly polyphagous, mobile species like *H. armigera*, and does increased pheromone production mean increased mating success?

The aims of this study were to examine the effects of host plants and their volatiles on maturation rate, mating behaviour and mating success in *H. armigera*. These results will help us understand the ecology of *H. armigera* in multi-crop environments, and how different crops can be used in management (e.g. refuges, trap cropping). We conducted laboratory experiments to determine whether host plant volatiles affected sexual maturation of females, female calling behaviour, female pheromone production and male responses to pheromones. We then looked at field experiments to determine whether mating success was dependent on the host crop surrounding the moths.

The results of female response to host plant volatiles revealed that the presence of host plants does affect female behaviour. Generally, moths spend more time calling in the presence of host plant volatiles. Two- and three-day-old females were found to produce more pheromone when in the presence of host plant volatiles. This is the age at which females of this species normally mate.

Laboratory studies of male behaviour in the presence of host plants in a wind tunnel indicated that there are few effects of host plants on male response to female sex pheromones. We also looked at the effect of two compounds on male response to female sex pheromone in the field. Previous studies have suggested that male response to female sex pheromone is increased by Z-3 hexenyl acetate (*H. zea*) and phenylacetaldehyde (*S. frugiperda*). We found for *H. armigera* that there is evidence that plant volatiles detract from responses to pheromones in the field not enhance them.

Finally we looked at the mating success of female *H. armigera* in the presence and absence of host plants in the field. Host plants included cotton, sunflower, sorghum, soybeans and maize, as well as fallow land. Virgin wing-clipped females were placed in mating trays in three or four crops each night. Male and female abundance was measured by light and pheromone traps in each crop. Females were not more likely to be mated in any one crop than another, despite differences in abundance between crops.

The implications for management suggest host plants do not greatly affect the mating behaviour and mating success of *H. armigera*. Therefore, other factors are viewed as more important in selecting refuges (e.g. number of moths produced) or trap crops (e.g. attractiveness for oviposition).

Project Number: 2.2.3 AC

Semiochemical Approaches to Control of *Helicoverpa* Spp.

AIMS AND MILESTONES

The aims of this project are to:

- develop improved attractants based on plant volatile chemicals, for adult *Helicoverpa* spp., especially females
- conduct large-scale field trials of attract-and-kill techniques using female attractants or pheromones or both.

Milestones for Year 1 are to:

1. Develop improved female attractants from lab and field trials.
2. Characterise moth responses around lures using night vision and wind tunnel studies.
3. Determine best formulations to use in large-scale field trials, including insecticides.
4. Conduct negotiations with commercial companies and file patent claim(s) if warranted.

STAFF

Dr Alice Del Socorro, University of New England
Associate Professor Peter Gregg, University of New England
Mr Richard Tennant, Laboratory Assistant, University of New England
Mr Dan Alter, Senior Professional Officer, University of New England
Dr Chris Moore, Principal Chemist, Queensland Department of Primary Industries, Brisbane
Professor Jia-wei Du, Shanghai Institute of Entomology, China

PROGRESS

This project continues the work of an earlier one in the CRC for Sustainable Cotton Production. It aims to develop attractants based on plant volatile chemicals for adult *Helicoverpa* spp., especially females. We have screened a total of 40 plants, thirty six single chemicals and 28 chemical blends in an olfactometer, which tests their attractiveness to *H. armigera* females. We have also conducted a total of twenty-one field trapping trials testing 32 types of attractant lures.

Of the blends tested in the olfactometer, 20 were found to be very attractive. We investigated the effects of systematically adding complexity to chemical blends, either within groups of leaf volatiles or floral volatiles, or by combining the two. Two of these blends were highly attractive in the olfactometer. We analysed the hairpencils of male moths to identify chemicals in male pheromones that might modify close-range attractiveness of female moths to our volatile blends. Initial field trials using blends combined with the fatty acids and their alcohol equivalents found in the hairpencils did not yield significant increase in trap catches. An electric grid trap was designed to improve trap catches in the field. This type of trap caught about five times more than the AgriSense® canister traps using pheromone lures. We have not yet tested it using plant volatile blends.

We designed an innovative field wind tunnel and used it in a total of 17 trials involving twenty seven wind tunnel/nights to test various types of formulations, and to characterise moth responses around lures using night-vision glasses. On nights when the weather was suitable, many moths were observed to approach the lure. Characteristic plume-following and hovering flight behaviour indicated they were responding to the volatiles. Many moths made repeated approaches to the lures, hovered then backed off. Behavioural observations suggest that there are specific close-range stimuli (chemical or visual) that are missing from the way we present lures in field wind tunnels and probably traps. Work on analysis of substances in male hairpencils and role of visual cues (e.g. artificial flowers) will be continued.

Feeding experiments under laboratory and field conditions were conducted to determine if moths would ingest a formulation containing the volatiles, a feeding stimulant and a toxicant, and to see if ingestion of the formulation would kill moths. A dye, Brilliant Green, was added so that moths could be dissected to determine whether they had ingested the material. Two types of formulations were used: water/oil mixtures and 'sloppy' SireneÒ. Insecticides used were either 1% carbaryl or 1% methomyl. Small droplets (50-100mL) of the formulations were placed in a 1L container with the moths. Kill rates with the formulation in 1% carbaryl were between 69 and 94%. With 1% methomyl the kill rate was 100%. 'Sloppy' SireneÒ formulations did not separate and retained liquidity overnight, making them more suitable than the water/oil mixtures that have previously been used for such products.

A provisional patent application, 'Attractants for moths", (Patent No. PR4797) was lodged with the Australian Patent Office in May 2001. Expressions of interest in supporting this work have been received from a number of semiochemical and pesticide companies.

Project Number: 2.2.4 AC

Bioremediation Enzyme for Endosulfan Sulfate

Milestones for this project are:

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 this emzyme.

STAFF

Dr John Oakeshott, Biotechnology Program Leader, CSIRO Entomology, Canberra
Dr Irene Horne, Post Doctoral Fellow, CSIRO Entomology, Canberra
Ms Kahli Weir, Technical Officer, CSIRO Entomology, Canberra
Dr Anthony Zera, University of Nebraska

PROGRESS

Endosulfan is a cheap and efficacious insecticide for the cotton industry but its ongoing availability is threatened by off-site residue problems. Applying endosulfan gives rise to three toxic residues. These are the alpha and beta isomers of the applied endosulfan, and endosulfan sulfate, which is a toxic breakdown product of alpha-endosulfan in particular. The sulfate is both more water soluble and more persistent in the environment than the parent endosulfan compound. It is produced in contaminated soil, and then washed off in irrigation or rainwater. It can survive in the soil/water for several months and so there is an ongoing threat of contaminated water leaving the farm. Of the three compounds, endosulfan sulfate is the major long-term contaminant of downstream water (albeit the parent isomers predominate in the first few days after application) and it is the major component of the residues found in contaminated beef.

The aim of this project is to isolate an enzyme capable of single step detoxification of endosulfan sulfate and to evaluate its efficacy in cleaning up contaminated run-off water. The goal of this project for 2000-2001 was to isolate a bacterium capable of degrading endosulfate to a non-toxic compound. This goal was achieved and the isolated bacterium is now being investigated as a source of a gene enzyme system capable of detoxifying endosulfan sulfate.

Project Number: 2.2.5 AC

Molecular Diagnosis of *Fusarium* Wilt of Cotton in Australia

AIMS AND MILESTONES

Fusarium wilt of cotton, (caused by *Fusarium oxysporum* f.sp. *vasinfectum)* (*Fov*), has emerged as a major threat to cotton production since it was first recorded in Australia in 1993. We are proposing to develop a DNA-based diagnostic test for *Fusarium* wilt that will allow more rapid and accurate disease diagnosis and better disease management. This diagnostic test will enable the rapid detection and identification of *Fov* from infected plants, infested soil, and cottonseed. It would also be a useful research tool to monitor the distribution and spread of *Fusarium* wilt throughout the cotton production areas of Australia, and to evaluate the effectiveness of different agronomic practices (e.g. crop rotation) on the survival of *Fov* in affected fields.

The milestones for 2000-2001 were to:

1. Establish a more extensive collection of isolates of *Fov* from overseas, especially from the USA (as the most likely source of introduction), Africa and Sudan.
2. Compare Australian genotypes of *Fov* with overseas VCG and races, using various molecular methods, e.g. DNA fingerprinting, sequencing the IGS region of the rDNA and sequencing other genes such as ß-tubulin.
3. Characterise the different genotypes distinguished by DNA fingerprinting analysis using vegetative compatibility group (VCG) analysis.
4. Establish the genetic relatedness of *Fov* to other *formae speciales* of *F. oxysporum*.
5. Evaluate the specificity of the available primers by screening them against other *Fov*, fusaria, fungi, microbes and plants.
6. Identify other DNA fragments unique to the two Australian genotypes of *Fov* (if necessary).
7. Develop/refine suitable methods for extracting DNA from infected plants, infected seed and infested soil.
8. Determine the sensitivity of the PCR-based test for detecting *Fov* in infected plant tissue, infected seed and infested soil.

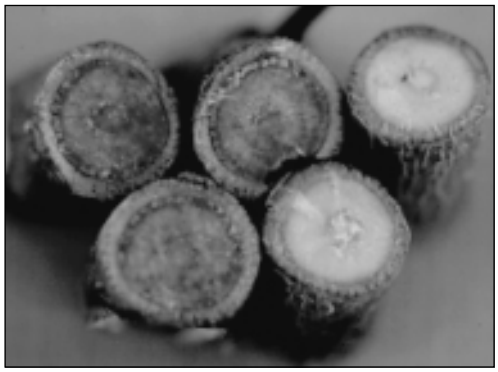
STAFF

Dr Suzy Bentley, Senior Research Officer, CRC for Tropical Plant Protection, Indooroopilly
Ms Lisa Gulino, PhD student, Cotton CRC/CRC for Tropical Plant Protection, Indooroopilly
Dr Natalie Moore, Senior Plant Pathologist, DPIQ, Indooroopilly
Dr Joe Kochman, Principal Plant Pathologist, DPIQ, Toowoomba
Mr Wayne O'Neill, Experimentalist, DPIQ, Indooroopilly
Miss Julie Pattemore, Research Officer, CRC for Tropical Plant Protection, Indooroopilly
Dr Stephen Allen, Senior Plant Pathologist, Cotton Seed Distributors, Narrabri

PROGRESS

A collection of Australian and overseas isolates of *Fov* that represents all the different races and vegetative compatibility groups (VCGs) that occur has been established, including isolates originating from different geographical regions. This collection of

Fusarium *wilt can devastate cotton crops.*



isolates of *Fov* is being extensively characterised using a number of different molecular techniques, including DNA amplification fingerprinting (DAF) analysis, restriction enzyme (RE) haplotyping analysis of the intergenic spacer (IGS) region of the ribosomal DNA (rDNA), DNA sequencing of the IGS region of the rDNA, and sequencing of other genes such as the mitochondrial small sub-unit (mtSSU) and α-elongation factor (α-EF) genes. The Australian isolates of *Fov* are being compared to overseas isolates of *Fov*, other formae speciales of *F. oxysporum*, non-pathogenic isolates of *F. oxysporum*, and other species of *Fusarium*, to determine the genetic relatedness amongst these groups.

The isolates of *Fov* have been characterised by DAF analysis with ten different arbitrary primers, and the genetic relationships amongst the Australian isolates of *Fov*, and the other groups examined have been determined. The IGS haplotyping analysis using five different restriction enzymes is in progress. The IGS sequencing analysis of selected isolates is mostly complete. DNA sequencing of the mtSSU and α-EF genes has not started yet.

DNA sequence information that is unique to the Australian pathotypes of *Fov* has been identified, and primers that specifically amplify the Australian strains of *Fov* developed. Two sets of PCR primers have been developed that specifically amplify DNA from each of the Australian VCGs 01111 and 01112. Database searches of DNA sequence information published in Genbank have indicated that there are no matches for these primers with any other organism, and laboratory screening of the specificity of these primers is nearly complete. So far, the primers have amplified only DNA from Australian isolates of *Fov* in VCGs 01111 and 01112 and not DNA from the other strains of *Fov*, other *formae speciales* of *F. oxysporum*, other species of fusaria, other fungi and bacteria that have been tested.

The PCR reaction conditions have been optimised for each of the sets of primers (in particular the annealing temperature which affects reaction specificity). Under these optimal conditions the PCR test is working very efficiently with very strong amplification of the specific PCR products being achieved. At present, the PCR tests for each VCG are performed in separate reactions, but we are aiming to combine the two sets of primers into a multiplex reaction that will detect both VCGs in a single reaction. Preliminary results indicate that the multiplex PCR test is able to differentiate Australian VCGs 01111 and 01112 of *Fov* from overseas isolates of *Fov*, and other *formae speciales* of *F. oxysporum*.

The current focus of the laboratory work is to optimise PCR amplification directly from infested soil, infected plant material and contaminated seed. This diagnostic test is being developed in collaboration with C-Quentec Diagnostics and relies on soil DNA extraction methodologies developed by Drs Kathy Ophel-Keller and Alan Mackay from SARDI (whereas the methods for DNA extraction from plant and seed will be developed in our laboratory). Preliminary experiments have shown that the PCR diagnostic test is able to detect *Fov* from soil DNA extracts, extracted using the system developed at SARDI. More thorough testing of soil extracts is currently underway, as are experiments to optimise DNA extraction and PCR amplification directly from infected plant material and contaminated seed.

Program Three

Sustainable Farming Systems

INTRODUCTION

Program 3 is developing strategies for cotton production that encourage efficient use of resources while minimising inputs and impact on the environment. Key issues facing the industry include water use efficiency, management of pests and diseases, soil management, salinity risks and off-farm movement of inputs. A range of projects in Program 3 dovetail with these key issues. These reflect both new approaches to problems and opportunities that are not being addressed by other funding bodies or agencies. Throughout the program emphasis is placed on a farming systems approach to ensure that research is integrated into the broader cotton agroecosystem.

Particular emphasis is placed on the issues of: soil health covering links to salinity, diseases and crop rotations; water issues including water use efficiency and bioremediation of polluted water; and IPM, including weed and disease management systems. A key initiative in the environmental area has been the development of a new project to determine the nature and value of ecosystems services on which the cotton production depends. This builds on existing projects on environmental impacts of irrigation systems. Another new initiative will provide research and extension support for management systems in developing regions of southern NSW.

Martin Dillon with a trap crop of Sunflowers.

HIGHLIGHTS AND ACHIEVEMENTS

All of the projects in Program 3 have achieved their stated objectives. Key outcome areas include soils, water, diseases and farming systems. While this report focuses on those projects directly funded by the CRC, either in part or full, there is a much broader range of projects that fall under the umbrella of the CRC. These cover areas of insecticide resistance, much of the research into IPM systems, several disease management projects, application and development of cotton simulation models and a number of water use efficiency related projects. Collectively the Australian Cotton CRC has a comprehensive research portfolio around Sustainable Farming Systems.

Management of *Fusarium* wilt remains a high priority. Annual surveys have documented the spread of this devastating disease from the previous focal areas of the Darling Downs and Macintyre valleys, into the Macquarie Valley, the Upper Namoi Valley in NSW and the Baralaba and Dirranbandi regions in QLD. *Fusarium* 'nursery' fields have been set up to evaluate host plant resistance and facilitate the cotton breeding. Coupled with the research effort has been a well-coordinated effort by scientists in Program 3 and Program 5 to provide guidelines to industry to help identify and manage new outbreaks and critically to minimise further spread of the disease. The CRC-established *Fusarium* Research Coordinating Committee continues to monitor and coordinate research and extension initiatives.

Soils research continues as a major focus. Regional studies of soil physical and chemical characteristics and hydraulic properties have been undertaken. Areas of real or potential soil problems are being highlighted in soil quality maps linked with a geographic information system and research is in progress to better use information available from satellite imagery. A key objective is to bring together the large body of available soil information and to begin to use it to improve the soil-water balance models. These can be linked with weather information and the *OZCOT* cotton crop simulation model to allow more detailed questions to be asked about the impact of management practices on soils and plant growth. A major thrust for the new CRC is the issue of soil health and its relationship with soilborne plant diseases. A new project has started with a PhD student to investigate the interaction between the microbial diversity and species abundance in cotton soils and the incidence of root diseases. Sites have been selected from areas with soils thought to be either conducive or non-conducive to black root rot and first experiments are underway to investigate if the apparent disease suppression is at least partly biological in nature.

There are strong links between the CRC's soils research and issues of water use. These include water use efficiency, salinity and deep drainage. With significant support from the Natural Heritage Trust we have developed and applied techniques for mapping soils with potential salinity risks, both at a field and regional level using electromagnetic sensing systems. Quantifying salinity risks in the cotton industry remains a high priority. To address the underlying processes involved in salinity we have initiated a new collaborative effort to close the water balance on cracking clay soils of the northern Murray-Darling Basin. This initiative will involve collaboration among a range of research and funding agencies to directly measure the components of water balance: drainage, evapotranspiration and runoff, identify priorities for associated research and develop strategies to avoid unwanted environmental change.

Soils research in progress.

Farming systems research receives a significant boost with the appointment of a CRC Farming Systems Scientist showing a major commitment in this area. Key systems questions being addressed include large-scale 'earliness' experiments to investigate factors contributing to crop earliness, the investigation of stubble retention systems to reduce erosion and their possible link with reduced pest levels. The Farming Systems Scientist will also ensure improved co-ordination of the long-term CRC Farming Systems experiments to increase their value and integrity of information from them.

The development of IPM systems for cotton remains a high priority. Research linked to the CRC is continuing to address issues such as selective pest control, resistance management, area-wide management and trap cropping. Area-wide management and the development of regional IPM support groups driven by growers illustrate a significant change in attitudes toward pest management and an important point of collaboration with the National Cotton Extension Network. Strong interest in IPM and area-wide approaches is being supported by upgraded IPM guidelines for Australian cotton and by analysis that is consistently showing economic advantages for growers adopting "soft" IPM approaches to pest management. The development of cotton production in more southerly regions (e.g. Lachlan Valley) has increased demand for research into IPM for these regions. As a result the CRC has established a research and extension team at Griffith, with a research entomologist working across both the cotton and grains industries and an industry development officer to help implement sustainable IPM and farming systems.

The profile of environmental issues has also been boosted in the program. A new project has been initiated to investigate the potential for 'on-farm' bioremediation of irrigation tailwater. This project seeks to use a linked system of artificial wetlands and microbial degradation chambers to reduce levels of potential contaminants in tailwater so providing greater opportunities for reuse and reducing environmental loads on-farm.

Another new initiative is a project to determine the nature and value of ecosystem services provided to the cotton industry by the environment. Ecosystem services are natural processes that result in the provision of clean water, productive soils, beneficial insects and pollination. This project aims to estimate the economic value of those services and is linked with the national CSIRO and Myer Foundation project that is currently investigating ecosystem services in other agricultural systems. The project has a catchment level focus (Gwydir Catchment), and has support from a range of agencies including the Natural Heritage Trust, NSW Department of Land and Water Conservation, the Cotton Research and Development Corporation and the Gwydir Valley Irrigators Association.

LINKAGES

Program 3 maintains linkages with industry, other research organisations and community groups. Strong links remain between the key research providers and the industry core partners via a wide range of formal and informal forums. Other linkages contribute funding or coordination to other components of Program 3, including:

- Salt Action and the National Heritage Trust contributing funding towards salinity research
- links with the CRC for Tropical Plant Pathology in *Fusarium* research
- links with the Department of Natural Resources and Mines Queensland in irrigation and soils research
- links with CSIRO Sustainable Ecosystems and NSW Department of Land and Water Conservation in the ecosystems services study
- links with the GRDC for funding and coordination of area-wide management on the Darling Downs and IPM research in southern cotton regions
- links with the regional grower and irrigator associations in funding applications for salinity research
- links with a wide range of CRDC funded projects, including many in-kind contributions
- CSIRO Land and Water, Adelaide (joint research role of organic matter in maintaining soil structure) and Canberra (collaboration in the soil baseline study)
- links with the Agricultural Production Systems Research Unit (CSIRO and QDPI)
- Weeds CRC for existing research and future joint opportunities in Queensland.

Project Number: 2.2.16

Sources of Beneficial Insects Colonising Cotton Fields

AIM AND MILESTONES

The aim of the project is to investigate the origins of beneficial insects that colonise cotton fields, using quantitative sampling methods and insect-borne pollen as a marker or origin.

Milestones in Year 3 (2000-2001) are to:
1. Conduct sampling for beneficial insects during the first 3 months of the season.
2. Examine pollen carried by these insects.
3. Analyse data and prepare publications.

STAFF

Dr Peter Gregg, Associate Professor, University of New England
Dr Letitia Silberbauer, Junior Research Fellow, University of New England
Dr Alice Del Socorro, Research Officer, University of New England
Mr George Henderson, Technical Officer, University of New England

PROGRESS

IPM in cotton requires maximising the impact of beneficial insects (predators and parasites). Techniques are being developed to encourage colonisation of cotton fields by these insects (e.g. the Envirofeast/lucerne strip system). However, the benefits of such systems will not be fully realised until we know more about the origins and ecology of beneficial insects colonising cotton, i.e. the distances they move, the role of non-crop vegetation (weeds and native vegetation), and the importance of alternative crops and alternative prey.

This project investigated some basic questions about the ecology of beneficial insects in and around cotton; namely where they occur, in both time and space, and how much they move around between vegetation types. There were two complementary parts to this study. The first was a survey, using suction samplers, of beneficial insects in cotton and in vegetation types near cotton. The second was examining beneficial species for pollen using scanning electron microscopy.

We focused on six species of insects known to be predatory on cotton pests: transverse ladybird, *Coccinella transversalis;* two spotted ladybird, *Diomus notescens;* nabid bug, *Nabis kinbergii;* red and blue beetle, *Dicranolaius bellulus;* green lacewing, *Mallada signata;* and brown lacewing, *Micromus tasmaniae*. Samples were taken using a suction sampler, D-vac, which is the most common method, besides visual sampling, used by agronomists and consultants working in cotton.

All the beneficial species monitored showed very different patterns of abundance and distribution in both time and vegetation type and there was also high variability within species. Scanning electron microscope examination of pollen from the six target insect species suggested that individuals move often between vegetation types and use a wide range of vegetation types.

Project Number: 5.3.1

Determining the Phosphorus (P) Requirements of Cotton Grown on Alkaline Soils in Australia

AIMS AND MILESTONES

The aims of the project are to:

- identify the critical soil and plant P limits for cotton
- investigate the benefits of P fertilisation on early crop vigour, crop maturity and lint yield
- improve confidence in interpreting soil and plant tissue tests.

Project milestones for Year 3 are as follows:

1. Complete field experiments in P deficient sites within the cotton belt.
2. Monitor P nutrition of cotton crops in field 6 at ACRI and CRC cropping system sites.
3. Conclude evaluation of soil and plant tests to determine critical P levels related to crop performance.
4. Conclude evaluation of P nutrition of physiologically-stressed cotton.
5. Disseminate research results *via* scientific papers, newsletters, industry magazines and grower field days.

STAFF

Chris Dorahy, Ph.D student at University of New England
Dr Ian Rochester, CSIRO Plant Industry, Narrabri
Associate Professor Graeme Blair, University of New England
Mr Greg Roberts, CSIRO Plant Industry, Narrabri

PROGRESS

Seventeen P response experiments were established throughout the cotton growing regions of NSW and southern Queensland between 1997 and 2000 to establish when soil P is limiting to cotton growth. Only three sites demonstrated a significant lint yield response to P fertiliser application, which indicated that most soils studied were able to supply the crops with their P requirements. A range of soil tests were also evaluated for their ability to predict when cotton will respond to P fertiliser. The Colwell P test gave the best correlation between soil P and cotton lint yield. It is suggested that the critical soil P limit for the Colwell P test is 6 mg/kg (0 to 30 cm).

Apparent P fertiliser recovery in the field experiments was variable (from 0 to 67%) so during the 1998-99 season a study was conducted at the ACRI, Narrabri to determine if this contributed to the lack of response that was observed. The objectives of this experiment were to estimate the fate of banded P fertiliser in the soil and to calculate how much of the fertiliser was recovered by the plants.

About half of the P became unavailable soon after application, although enough P remained available in the soil to increase early season P uptake. The cotton plants recovered 35% of the P fertiliser that was applied. Despite this, there weren't any differences in lint yield between the P-fertilised and unfertilised plants, which indicated that the plants met their P requirements from the soil as they became established. Therefore, P fertiliser application will only be beneficial when soil P is limiting.

It is concluded that most Australian cotton soils are able to supply cotton with its P requirements. Banding MAP at a rate of 20 kg P/ha is recommended as Colwell P concentrations approach 6 mg/kg (from 0 to 30 cm) to maintain soil P reserves and avoid P deficiency. Below this concentration higher rates of P application are recommended.

Project Number: 3.1.0 AC

Long-Term Effects of Cotton Rotations on the Sustainability of Cotton Soils II

AIMS AND MILESTONES

The aims of this project are to determine the long-term effects of rotation crops and their management on soil quality changes, nutrient uptake and cycling, growth and yield of succeeding cotton, and profitability on Vertosols used for irrigated and dryland cotton production in NSW and Queensland.

Project milestones were as follows:

1. Take soil samples from all experimental sites at Warren, Merah North, Wee Waa, Warra and Emerald for analysis. Perform on site measurements of soil properties where required. Complete laboratory analyses and perform data analyses on the results.
2. Prepare land and sow cotton in all experimental sites.
3. Monitor growth and nutrient uptake by cotton crops in NSW sites.
4. Collect economic data and evaluate farm profitability in NSW sites.
5. Monitor nutrient leaching and drainage at the Wee Waa and Merah North sites and the minimum tilled wheat-cotton rotation site at ACRI.
6. Conduct any additional experiments if required.

STAFF

Dr N. Hulugalle, Research Scientist, NSW Agriculture, Narrabri
T. Weaver, Technical Officer, NSW Agriculture, Narrabri
F. Scott, Technical Officer, NSW Agriculture, Narrabri
L. Finlay, Technical Officer, NSW Agriculture, Narrabri

PROGRESS

At Warren, effects of the rotation crops, which were last sown in 1998, were still present. In this experiment continuous cotton had poorest soil structure and nitrogen uptake. Ex-legume plots had next poorest soil quality. At Wee Waa, there was more cruciferous weeds in the ex-legume plots. Because of the combination of intensive tillage and laser levelling in some plots at Wee Waa, effects of the rotations on soil properties at Wee Waa and Emerald were absent. At Warra, however, soil structure was poorest where only cotton had been sown since 1993. Soil salinity at Merah North was highest with continuous cotton, and subsoil structure was best where either cotton-wheat or long-fallow cotton had been sown.

Cotton was sown at all NSW sites in October 2000, delayed at the Warra dryland site because of low winter rainfall, and not sown at Emerald as our cooperator decided to sow long-fallow wheat. Cotton growth was poor at Merah North because it was irrigated with saline bore water and the cropped virtually stopped growing by mid January 2001.

Nutrient leaching, soil and water quality were measured using a combination of ceramic water samplers, EM38 surveys and soil sampling at Wee Waa, Merah North and ACRI (where the cotton was sown into standing wheat stubble). In all sites there were nitrate, chloride and drainage losses out of the rootzone throughout the growing season, but drainage and nitrate leaching occurred more often during the first half. Nitrate concentration in deep drainage was generally between 100 and 200 mg/L. At all sites drainage and nutrient leaching occurred more often at the taildrain end of the field. At Merah North, most drainage events took place in continuous cotton plots. In all sites both leaching and drainage varied greatly across a transect indicating a high degree of spatial variability. Preliminary estimates of drainage suggest that, depending on the age and health of the crop, quality of water and location in the field, between 0 and 13% of each 1 ML of irrigation water can be lost as drainage. However, most estimates fell between 5 and 8%. Gross margins were lowest at Merah North with cotton-wheat rotation having the highest gross margin. The gross margins at Merah North were about 1/20th to ¼ of those at Wee Waa. The low gross margins were probably due to the saline bore water used for irrigation, and consequent fall in crop yield.

A laboratory experiment to find out the effects of rotation crop stubble (green and mature wheat, faba bean, cotton, soybean) breakdown on soil organic and inorganic carbon (C) in a sodic grey clay was completed. A field experiment to measure the decomposition of cotton and wheat stubble and their effects on soil organic and inorganic C under different tillage systems was also done at ACRI, where cotton in the rotation plots was sown into standing wheat stubble. Soil was sampled at monthly intervals commencing in January 2000. Soil analyses are ongoing for both sets of experiments.

Project Number: 3.1.2 AC

Identification and Remediation of Nutritional Stresses in Cotton Crops

AIMS AND MILESTONES

The aims of this project are to:

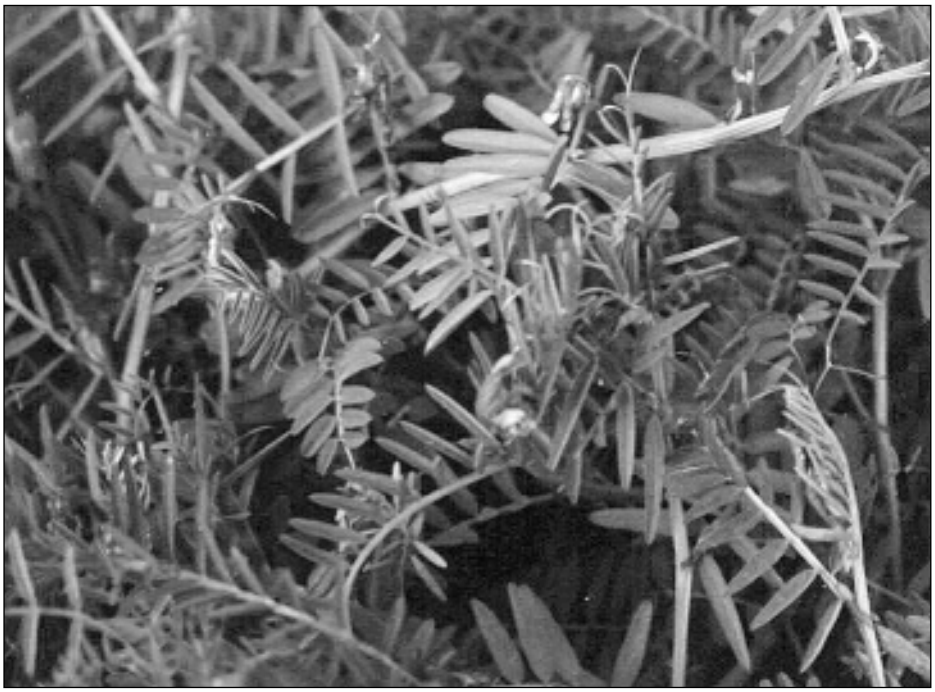
- identify critical nutrient concentrations in cotton leaves
- develop techniques for rapid assessment of nutrients in cotton leaves
- continue development of N-efficient cropping systems using legumes
- assess soil quality improvement associated with legume cropping.

There were a number of milestones for Year 1, as follows:

1. Assess winter forage legume crops grown between cotton crops for N fixation and fertility of each system.
2. Collect cotton leaf samples from diverse fertility samples for comparative nutritional analyses and assess nutritional requirement of experimental and commercial cotton crops using leaf analyses.
3. Compare summer and winter growing legume crops with respect to soil amelioration.
4. Assess root exudate production by legume species to relate to changes in soil quality.
5. Monitor fertility status regularly in field experiments using soil and plant analyses.

STAFF

Dr Ian Rochester, CSIRO Plant Industry, Narrabri
Mr Greg Roberts, CSIRO Plant Industry, Narrabri
Dr Mark Peoples, CSIRO Plant Industry, Canberra
Dr Peter Hocking, CSIRO Plant Industry, Canberra



Vetch is a crop with the potential to add nitrogen to soils.

PROGRESS

Winter forage (vetch) crops grown between cotton crops and after wheat produced about 3 t DM/ha and fixed around 160 kg N/ha, slightly less than in previous years because of the dry conditions. A vetch cultivar trial indicated that Namoi Woolly Pod produced the highest DM and fixed more N than other commercial cultivars. Cotton yields indicated that little N fertiliser (60 to 80 kg N/ha) was required where vetch was grown between continuous cotton crops. Interestingly, where vetch was grown after wheat the following cotton required no N fertiliser.

Leaf samples collected from many cotton fields from several valleys during the 2000-2001 season indicated low levels of P, potassium (K) and zinc (Zn) in many crops. The influence of sodium on the uptake of P and K is substantial. Where there are high levels of sodium in the soil it appears to inhibit P and K uptake. This is being further investigated in a small glasshouse experiment.

Soil strength was reduced by 10% following vetch cropping as assessed during the growth of the cotton crop. A glasshouse experiment to assess legume crop root exudation indicated that some legume crops (notably soybeans and cowpeas) can acidify their root environment and may thereby alter nutrient availability more than non-legume crops. These changes in soil pH were also observed to a lesser degree in soil sampled from the field experiments.

A further glasshouse experiment to assess the nutritional effects of elevated soil sodium levels on crop nutrition will start in 2001. While salinity is thought not to substantially affect cotton production, the associated problem of soil sodicity (high sodium content) is of concern in many cotton soils. Leaf samples collected in 2000-2001 indicate high sodium levels in cotton plants.

The evaluation of the SPAD meter has indicated substantial variation between commercial cotton cultivars and these variations will be built into the final SPAD package.

Project Number: 3.1.3 AC

Integration of Agronomy, Crop Physiology, and Model Development and Validation

AIM AND MILESTONES

The aim of this project is to improve interaction of agronomic, crop physiology and modelling research activities. By providing additional resources it will contribute to the following specific project objectives by:

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

Year 1 milestones were as follows:

1. Assist with field experiments to validate model to account for differences between long and short seasoned cotton genotypes.
2. Collect and process data to demonstrate the value of linking crop and soil monitoring with the predictive capability of simulation models (ongoing project in collaboration with APSRU).
3. Assist with studies into research into the relationships between foliar nitrogen and photosynthesis.
4. Assist with collection of data in waterlogging studies.
5. Assist with collection of data from off station experiments.
6. Collate data, enter in spreadsheets and undertake preliminary analysis.

STAFF

Dr Michael Bange, Senior Research Scientist, CSIRO Plant Industry, Narrabri
Dr Stephen Milroy, Research Scientist, CSIRO Plant Industry, Narrabri
Mr Dirk Richards, Experimental Scientist, CSIRO Plant Industry, Narrabri
Ms Tanya Smith,Technical Assistant, CSIRO Plant Industry, Narrabri
Dr Sunil Tennakoon, Experimental Scientist, CSIRO Plant Industry, Narrabri
Dr Pongmanee Thongbai, Post-Doctorate, Crop Waterlogging, CSIRO Plant Industry, Narrabri

PROGRESS

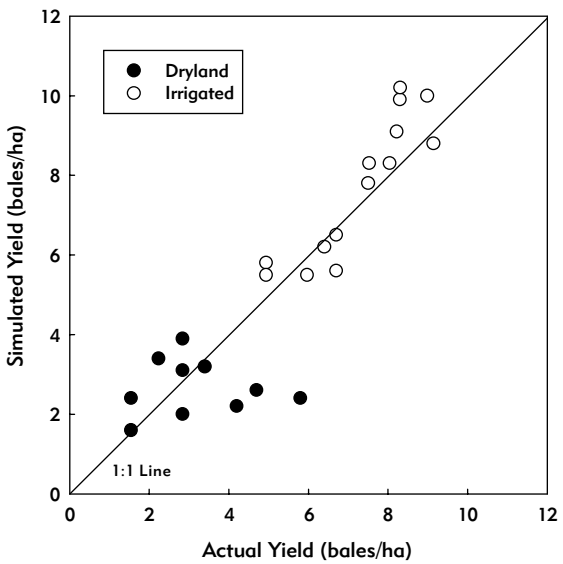
Technical assistance was provided to assist with the following experiments conducted in the 2000-2001 cotton season:

- A field experiment using short and long season cultivars to collect information on the dynamics of cotton fruit production.
- A large field experiment to investigate the physiological responses of waterlogging on crop growth. This included measurements of leaf photosynthesis, fruit counts, collection of leaves for nitrogen analysis, leaf chlorophyll, retrospective mapping of fruit position, soil-water content, biomass sampling, light interception, maturity picks and yield.

Tanya Smith, Cotton CRC technical assistant in cotton crop physiology and agronomy, measuring leaf photosynthesis in a glasshouse experiment.

- A large field experiment to evaluate the performance of eight transgenic lines with enhanced alcohol fermentation to waterlogging in the field.
- A field experiment investigating the physiological effects of an exogenous inhibitor (AVG) on waterlogged cotton and efficacy for field use.
- One on-farm experiment was conducted collaboratively with growers. The experiment collected information on the effects of crop growth from frequent irrigations postulated as a means of improving in field water use efficiency. This data will be used to validate a simulation model, which will be then used to further evaluate the frequent irrigation concept. These experiments involved numerous measurements of soil water extraction throughout the duration of the crop.
- A field experiment with three different nitrogen treatments was conducted with leaf photosynthesis measured often. The individual leaves on which photosynthesis was measured were collected for nitrogen analyses. Information will be used to derive responses of photosynthesis to leaf nitrogen concentration. This information will be used to try to improve the simulation model's response to nitrogen.
- A total of eight soil characterisation sites have been sampled and data processed for use in cropping systems models. In addition, a further 21 fields, both irrigated and dryland cotton crops at the start of the season, were sampled for soil moisture and nitrogen to depth for modelling benchmarking exercises with grower groups.
- A glasshouse experiment was conducted to explore the effects of modifying carbon supply with different fruiting characteristics.

Figure 5. Simulated yields versus actual measured paddock yields compiled for the *OZCOT* crop simulation model (R^2 = 0.81).



Project Number: 3.1.5.AC

Sustainable Weed Management Systems for Cotton

AIM AND MILESTONE

The aim of this project is to identify cotton fields with low weed pressure and to examine and develop sustainable, low input weed management systems for these fields using new technology and reducing the dependence on herbicides and cultivation.

The project milestone in Year 1 is to identify suitable low weed pressure fields and identify major weeds, weed seed bank status and other sources of infestation.

STAFF

Dr Ian Taylor, NSW Agriculture, Narrabri
Ms Benita Inchbold, NSW Agriculture Narrabri

PROGRESS

Weed surveys (both grower interviews and in-field) were conducted on 25 farms during the current season to determine the number and type of weeds present and to identify farms with low weed pressure. The surveys were conducted from Narrabri (lower Namoi) through to Biloela in central Queensland, excluding the Darling Downs Region. A total of 72 weed species were observed. The ten most commonly encountered weeds included bladder ketmia, barnyard grass, native sensitive plant, nutgrass, sowthistle, peach vine, liverseed grass, sesbania pea and annual ground cherry. The rating system used to categorise the weeds was based on the percentage of farms infested with the weed and the number of weeds encountered in the field surveyed and may not necessarily reflect those weeds that are the most difficult to control.

In the oral survey growers were asked to identify weeds that were present on their farms and were more difficult to control. The ten weeds identified by growers as problematic were peachvine, nutgrass, noogoora burr, bathurst burr, sesbania pea, datura, sowthistle, bladder ketmia, annual ground cherry and barnyard grass. The obvious major differences between the grower surveys and the in-field surveys are the identification by the growers of the burrs (noogoora and bathurst) and thornapples as major weeds in cotton farming systems. These species were detected on 35, 20 and 25% of the total number of fields surveyed respectively and were included in the top twenty weeds in the field surveys. From a grower perspective these three weeds are likely to have a greater impact on yield and harvest quality and therefore would be of greater concern than some of the other more commonly occurring weeds.

The main aim of the surveys was to locate fields where the weed pressure was low enough to allow experimental trials with reduced residual herbicide inputs to be conducted. Several fields were identified after completing the surveys. Soil cores (1600) were then extracted from these fields to determine the number and type of weeds contained in the soil seed bank. These cores are at present being grown out in a glasshouse and final field selection will take place in the next three months.

Table 3. Weed species observed in physical surveys of irrigated cotton farms ranked from most problematic to least problematic including the percentage of farms surveyed infested with the weeds during the 2000-2001 cotton season.

	Common name	Species name	% farms present		Common name	Species name	% farms present		Common name	Species name	% farms present
1	Bladder ketmia	*Hibiscus trionum*	80	25	Couch grass	*Cynodon dactylon*	15	49	Budda pea	*Aeschynomene indica*	15
2	Barnyard grass	*Echinocloa crus-galli*	70	26	Raspweed	*Haloragis Glauca*	25	50	Flea bane	*Conyza* spp	15
3	Native sensitive plant	*Neptunia gracilis*	65	27	Anoda weed	*Anoda cristata*	20	51	Feather top rhodes grass	*Chloris virgata*	10
4	Nutgrass	*Cyperus* spp.	60	28	Bathurst burr	*Xanthium spinosum*	20	52	Green panic	*Panicum maximum*	10
5	Sowthistle	*Sonchus oleraceus*	60	29	Maloga bean	*Vigna lanceolata*	20	53	Plains spurge	*Euphorbia planticola*	10
6	Peachvine	*Ipomea lonchophylla*	55	30	Variegated thistle	*Silybum marianum*	20	54	Teucry weed	*Teucriumn integrifolium*	10
7	Bokhara clover	*Melilotus alba*	50	31	Dwarf amaranth	*Amarathus macrocarpus*	10	55	Dalrymple vigna	*Vigna luteola*	10
8	Liverseed grass	*Urochloa panicoides*	40	32	Petty spurge	*Euphorbia peplus*	10	56	Wildoats	*Avena fatua*	10
9	Sesbania pea	*Sesbania cannabina*	40	33	Caustic weed	*Chamaesyce drummondii*	15	57	Bishops weed	*Ammi majus*	5
10	Common sida	*Sida rhombifolia*	45	34	Charlock	*Sinapsis arvensis*	15	58	Button grass	*Dactyloctenium radulans*	5
11	Annual ground cherry	*Physallis ixocarpa*	45	35	Small flowered mallow	*Malva parviflora*	15	59	Faba bean	*Vicia faba*	5
12	Cathead	*Tribulus terrestris*	25	36	Phasey bean	*Macroptilium lathyroides*	15	60	Hairy wnadering Jew	*Commelina benghalensis*	5
13	Thornapple	*Datura* spp.	25	37	Grey rattlepod	*Crotalaria dissitflora*	10	61	Knot weed	*Polygonum aviculare*	5
14	Yellow vine	*Tribulus micrococcus*	25	38	Other annual grasses	*Poaceae* spp.	10	62	Lesser swinecress	*Coronopus didymus*	5
15	Australian Bind weed	*Convulvulus erubescens*	40	39	Mint weed	*Salvia reflexa*	10	63	Native millet	*Panicum decompositum*	5
16	Rhyncosia	*Rhyncosia minima*	40	40	Amaranth (red root)	*Amaranthus retroflexus*	5	64	Nodding thistle	*Carduus nutans*	5
17	Noogoora Burr	*Xanthium occidentale*	35	41	Black pigweed	*Trianthema portulacastrum*	25	65	Onion weed	*Asphodelus fistulosus*	5
18	Bellvine	*Ipomea plebia*	20	42	Slender celery	*Ciclospermum leptophyllum*	5	66	Paddy melon	*Citrullus lanatus*	5
19	Polymeria pusilla	*Polymeria Pusilla*	20	43	Spiny headed sida	*Sida acuta*	25	67	Phyllanthus	*Phyllanthus virgatus*	5
20	Polymeria take-all	*Polymeria longifolia*	20	44	Blackbindweed	*Polygonum convulvulus*	5	68	Wild gooseberry	*Physallis minima*	5
21	Burr medic	*Medicago* spp.	30	45	Euphorbia	*Euphorbia hyssopifolia*	5	69	Spear thistle	*Cirsium vulgare*	5
22	Field Bind weed	*Convulvulus arvensis*	30	46	Jute	*Corchorus olitorus*	5	70	Soft rolly polly	*Salsola kali*	5
23	Pigweed (red)	*Potulaca oleracea*	15	47	Tarvine	*Boerhavia diffusa*	5	71	Velvet leaf	*Abutilon*	5
24	Blackberry night shade	*Solanum nigrum*	15	48	Volunteer canola	*Brassica napus*	5	72	Volunteer sorghum	*Sorghum bicolor*	5

Project Number: 3.1.6 AC

Cotton Production Systems for Southern New South Wales

AIMS AND MILESTONES

The aims of this project are to develop acceptable IPM strategies for southern cotton production regions that include:

- optimising the use of native beneficial insect populations
- pest and beneficial host and refuge crops and cropping systems
- suitable insecticide resistance management strategies
- suitable area wide management strategies
- the use of appropriate insect thresholds.

Year 1 milestones were as follows:

1. Survey the major pests and beneficial insects.
2. Establish large scale IPM trial.
3. Expand existing *Helicoverpa* monitoring networks.
4. Examine native pest/beneficial refuges.
5. Establish initial refuge/host crop trials.
6. Establish regular resistance data.

STAFF

Dr Geoff Baker, Senior Principal Research Scientist, CSIRO Entomology
Dr Scott Hardwick, Experimental Scientist, CSIRO Entomology

PROGRESS

This project builds on previous work by Dr Simon Duffield and supported by GRDC. Dr Duffield had identified the key aspects of *Helicoverpa* dynamics in southern NSW and started developing IPM systems for some grain crops. With Cotton CRC and CRDC support the research entomologist is now jointly supported with GRDC and forms a team with a cotton industry development officer (yet to be appointed).

Unfortunately, Dr Duffield resigned in mid August 2000. He was replaced by Dr Scott Hardwick (recruited from New Zealand after advertisement and interviewing a strong list of applicants). Dr Hardwick began duties with CSIRO Entomology in Griffith in early October and established good linkages with local agronomists in NSW Agriculture (M. Parker and D. McCaffery). The early part of the season in southern NSW was unusually cold and wet, like much of the rest of NSW, while the mid and latter parts of the season were unusually warm and dry leading to an early harvest on most stations in the Hillston region.

A network of 11 pairs of pheromone traps were established in late August on six cotton growing stations in the Hillston area. The traps were maintained by station staff, who emptied the traps weekly and provided the data on moth numbers to CSIRO staff. These new trap sites extend a trap network that was previously established and is still running in the Murrumbridgee Irrigation Area under GRDC funding. Although trapping results from the 2000-2001 season indicated relatively low levels of flight activity by *Helicoverpa* spp. over the whole Hillston region, there were spatially isolated yet significant flights of *H. punctigera*.

During the growing season densities of egg, larval and pupae of *Helicoverpa* and beneficials were monitored in six early season chickpea trap crops, 14 cotton crops (six of which were INGARD varieties), three late season cotton trap crops and a late season pigeon pea trap crop. As well as direct monitoring made by CSIRO staff, access to egg and larval counts made by station staff was negotiated. Larval samples were sent to R. Gunning from NSW Agriculture for resistance testing.

A trial to investigate the relative attractiveness of late cotton, soybean, sunflower and pigeon peas to *Helicoverpa* in southern NSW was carried out at the CSIRO Land & Water laboratory in Griffith. The results showed that sunflower was highly attractive compared to the other three crops and may have some potential as an alternative late season trap crop in the region.

Project Number: 3.1.7 AC

Coordination and Promotion of Innovative Farming Systems Research

AIMS AND MILESTONES

The aims of this project are as follows:

- Initiate innovative farming systems experiments which combine a range of disciplines including soil science, crop agronomy, insect, weed, disease and water management. The objective is to develop viable and sustainable cotton cropping systems. Experiments identified in the project "Coordination and promotion of innovative Farming Systems Research" No. 5.1.5 funded by the CRC for Sustainable Cotton production will be the starting point and these include the concept of managing earliness in cotton and dryland weed management.
- Coordination of collaborative research and extension into cotton based farming systems including the core CRC systems trials.
- Promotion of CRC farming systems research at field days, conferences and industry press.

Year 1 milestones were to:

1. Continue the experimentation established in the previous year on three key areas (1. Managing cotton for earliness, 2. Stubble retained systems, and 3. Dryland weeds).
2. Coordinate collaborative research experiments that will be initiated after industry discussion on research and extension, including researchers and coordination in the north.
3. Coordinate and conduct experiments on the core CRC farming systems experiments at Merah north and Warra.
4. Promote results of cotton CRC farming systems experiments.

STAFF

Mr Grant Roberts, Research Scientist, CSIRO Plant Industry, Narrabri
Ms Clare Felton-Taylor, Technical Officer, CSIRO Plant Industry, Narrabri

PROGRESS

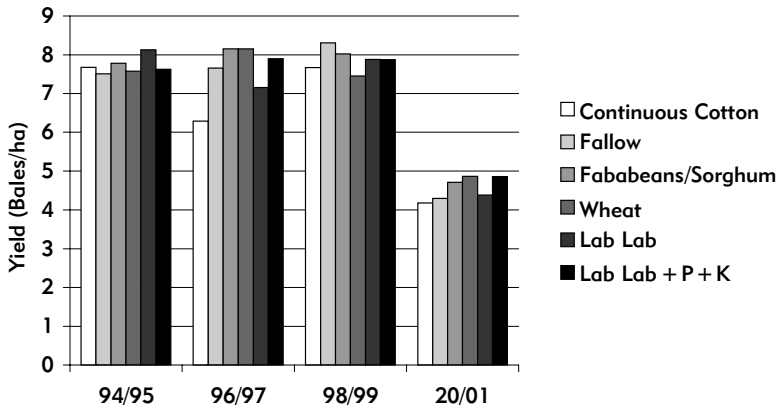
Farming systems topics examined this season included 'earliness', the effect of herbicide reduction on soil biology and rotational effects on cotton systems.

Previous attempts to identify the components of earliness could not determine the contribution of insect management compared to agronomy. Our experiments this year allowed management for earliness to be partitioned to examine the effect of agronomy (nitrogen, water, Pix and variety) and insect management (early, standard and excellent). Short season varieties always matured earlier, however, both agronomic and insect management (coupled with agronomy) enhanced maturity even further. The results indicate that both agronomy and insect management can influence earliness separately or interact together. Short season varieties, with reduced nitrogen, high fruit retention, reduced late season watering and appropriate management with Pix can shorten the period from planting to picking although there is a yield penalty associated with this. Larger scale evaluation of these concepts was also tested at one site.

We continued experiments on reduced residual herbicides with the use of Roundup Ready cotton in dryland systems. These experiments examined application timing and early season simulated insect damage. The latter experiment aimed to assess the likely impact of reduced glyphosate absorption if early season insect damage occurred. These results will help determine factors that may contribute to yield variation in unusual situations but, more importantly, how the technology will help reduce residual herbicide load to the system.

The medium term Merah North rotation experiment entered its eighth and final season. Unfortunately, because of conflicting commitments of our collaborators (the Grellman family) the experiment can no longer continue, however, it is hoped that some monitoring will continue for two years. Figure 6 demonstrates the yield of cotton after each rotation crop. There is variability amongst the rotation crops with no clear trend as to the highest yielding rotation. In years when the continuous cotton treatments yield was lower this does not appear to be associated with any measurable disease levels. The yield decline that occurred across all treatments in 2000-2001 season appears to be associated with decreasing quality of bore water (high sodium or chloride or both).

Figure 6. Cotton yield (bales/ha) after rotations crops at Merah North rotation experiment from 1994 to 2001.



Project Number: 3.1.8 AC

Ecology and Development of Management Strategies for *Fusarium* Wilt in Cotton

Aims and milestones

The aims of the project are to:

- monitor the diversity and distribution of strains of *Fusarium* wilt in growing areas in Australia
- develop a PCR-based detection system for *Fov*
- provide plant pathology support to 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
- develop and extend new management packages for disease management.

Project milestones for 2000-2001 were as follows:

1. Complete planting of field trials by December and complete assessment by July 2001.
2. Complete disease surveys to determine the extent of the *Fusarium* wilt affected area by the end of May 2001.
3. Complete the monitoring of pathogen diversity, maintain the reference collection and wilt incidence database by July 2001.
4. Develop primers specific for each unique DNA sequence of the Australian pathotypes of *Fov* by July 2001.
5. Develop information packages and extend to the industry, as results become available.

STAFF

Dr Joe Kochman, Principal Plant Pathologist, Queensland Department of Primary Industries, Toowoomba
Dr Natalie Moore, Senior Plant Pathologist, Queensland Department of Primary Industries, Indooroopilly
Dr Suzy Bentley, Molecular Biologist, CRC for Tropical Plant Protection, Indooroopilly
Mr Neale Obst, District Experimentalist, Queensland Department of Primary Industries, Toowoomba
Mr Wayne O'Neill, Experimentalist, Queensland Department of Primary Industries, Indooroopilly
Mr Greg Salmond, Senior Development Extension Officer, Queensland Department of Primary Industries, Dalby
Miss Julie Pattemore, Research Officer, CRC for Tropical Plant Protection, Indooroopilly
Miss Lisa Gulino, PhD student, co-funded by the CRC for Tropical Plant Protection and the Australian Cotton CRC, CRC for Tropical Plant Protection, Indooroopilly

PROGRESS

Despite limited irrigation water supplies, around 12 ha (29 acres) of field trials were planted at the Clapham's research site near Cecil Plains in October 2000 to assess germplasm reaction to *Fusarium* wilt. Initial emergence was excellent and there was significant disease pressure allowing for differentiation of the germplasm being screened. Data collected to date indicate that germplasm reselection, under disease pressure, will provide cultivars with improved resistance to the disease. Several lines have been identified, with improved survival and yield, which are much more resistant than the best current commercial cultivars.

Specific rotation trials could not be planted last season because of a lack of rain. A farmer survey was conducted instead to determine if there were any farming practices, which might have affected *Fusarium* development. Irrigated land has been set aside for

this season and a range of summer crops have been planted. Preplant soil bioassays for *Fusarium* wilt levels are in progress.

Cotton disease surveys have been completed in the Emerald/Theodore/Baralaba; Darling Downs; St George/Dirranbandi and Goondiwindi/Inglewood districts in consultation with cotton industry development officers and consultants in each district. No new cotton diseases were found in these surveys. Only one new case of *Fusarium* wilt was found on a farm that was previously considered to be free from *Fov* in the Dirranbandi area. New records of *Fov* were confirmed in the Burnett district (Byee) this season. No records of *Fov* have yet been made from the production areas of Emerald in Queensland, Tandou, Hillston and the lower/western Namoi Valley in NSW or in Western Australia. No new strains of *Fov* have been identified amongst the specimens received to date.

Several information packages have been distributed to growers and consultants in NSW and Queensland. A new Information Sheet, *Now that you have* Fusarium *wilt confirmed on your farm*, has been produced to complement others that have been produced for the Australian Cotton CRC.

Project Number: 3.1.11 AC

Dynamic Modelling of Soil Physical-Chemical Processes as Indicators of Soil Health in Relation to Land Use in Cotton Growing Regions

AIMS AND MILESTONES

The aims of this project are to:

- 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 stakeholders
- develop sampling protocols for the continual monitoring of soil health in relation to land use and agricultural productivity.

Milestones for 2000-2001 were as follows:

1. Demonstrate potential reduction or otherwise of greenhouse gas emissions in the lower Namoi Valley.
2. Complete work for St George and Bourke irrigation areas and the field survey to fill the gap between the lower Gwydir and Namoi valleys.
3. Continuous improvement of the digital soil information maps.

STAFF

Dr I.O.A. Odeh, Key Researcher, University of Sydney
Professor A.B. McBratney, Project Supervisor, University of Sydney
Dr B. Singh, Researcher, University of Sydney
Dr J. Triantafilis, Senior Research Scientist, University of Sydney
Ms M.S. Dunbar, Postgraduate Student, University of Sydney
Ms W. Soepboer, Visiting Student
Mr A. Onnus, Fourth Year Undergraduate Student — working on Bourke Soil Inventory, University of Sydney

PROGRESS

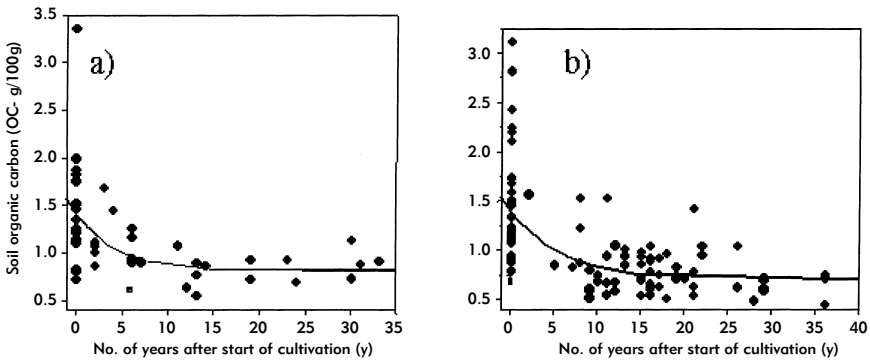
Soil organic carbon distribution and the potential for greenhouse gas emissions

Soil organic carbon is one of the most important of the world's capitals. The conservation of soil organic carbon is not only good for a healthy soil but also may lead to sequestration of carbon. The soil acts as sinks for greenhouse gases, especially CO_2. The focus

of our work this year is on estimating the total soil organic carbon stock and predicting carbon changes under different land uses in the cotton growing region of the lower Namoi and Gwydir valleys. To ensure that our model of carbon changes over time included as much variation as possible, an appropriate sampling design was implemented. Farm surveys were carried out to ascertain the year each of the sampled paddocks was cleared at the onset of or after European settlement. The stock routes and woodland areas are treated as at zero time. The time series and the organic carbon data were used to model the carbon changes over time, and hence sequestration or CO_2 emissions.

The models, as shown in Figure 7 for the lower Namoi and Gwydir valleys, account for about 35 to 40 % of organic carbon variation. Other factors such as climatic variation and subtle differences in soil types are probably responsible for the fairly large uncertainty in the models. In fitting the models, we assumed initial carbon input to be the average of the present organic carbon in the non-cultivated fields, which is about 1.6 %. Topsoil organic carbon declines rapidly to just under 0.9 % within seven years, which after then levels out within fifteen years (from the start of cultivation) to about 0.70 %, a value that approximates the average organic carbon for the fields that have been under continuous conventional cultivation. Significantly, this loss of organic carbon (due to conventional cropping on clay soils) over fifteen years could be averaged to about 11.2 t/ha C, which is equivalent to a loss of about 0.75 t/ha of C a year. It would be interesting to compare this result with the carbon loss under zero or minimum tillage.

Figure 7. Models of the topsoil organic carbon evolution as affected by tillage/land use in the a) Lower Namoi, and b) Lower Gwydir valleys



Field survey of soil to fill the gaps (Bourke and St George regions, and the area between the lower Namoi and Gwydir valleys)

Field soil survey and most of the soil laboratory analysis have been completed for St George and Bourke irrigation areas. Additionally, we have just completed the survey in the area between the lower Namoi and the Gwydir valleys, with a total of 76 sites visited and sampled. The laboratory analysis for the latter area was accomplished with the help of Ms W. Soepboer, a visiting student from the Netherlands.

Improvement of digital soil information maps

One of the most important aspects of this project is the provision of quality soil information to the end users. We are continuing to produce improved digital soil maps that are incorporated into a GIS. To achieve this satellite imageries at higher resolution (Landsat-TM-5 imageries at 25 m resolution) covering the whole project regions have been purchased.

Farming community survey on soil health

The modality of this survey is being worked out with an expert in sociological survey from UNE, Dr L. L. de Bruyn. We intend to carry out this exercise in conjunction with the Extension Network as part of the benchmarking surveys across the industry, to reduce cost.

Project Number: 3.1.12 AC

Cotton Soil Health: Influence on Cotton Root Diseases

AIMS AND MILESTONES

The aims of this project are to:

- quantify microbial communities in cotton soils by measuring functional diversity and species abundance
- determine how the incidence of root diseases of cotton is influenced by soil microbial diversity
- assess the impact of management practices on soil microbial diversity
- develop simple-to-measure indicators of soil health.

Milestones for Year 1 were:

1. Sampling sites selected and soil characteristics analysed.
2. First soil sampling and community level physiological profile (CLPP) analysis completed.
3. Progress made towards developing DNA extraction, purification and amplification protocols suited to soils from the chosen sites.

STAFF

Florian Yan, PhD Student, University of Sydney
Dr Les Copeland, University of Sydney
Dr Tony Vancov, NSW Agriculture
Dr David Nehl, Research Officer, NSW Agriculture
Dr David Backhouse, University of New England

COLLABORATORS

Dr I.O.A. Odeh (University of Sydney), Dr V Gupta (CSIRO Land & Water), Mr Grant Roberts (CSIRO Plant Industry).

PROGRESS

The incidence of black root rot (causal organism *Theilaviopsis basicola*) is known to be suppressed in certain cotton-growing soils, i.e. the level of disease incited is much less than expected given favourable environmental conditions and ample opportunity for the pathogen to become established. The cause of this disease suppression is not known, although there is circumstantial evidence to suggest that soil texture has some influence on disease severity. It is also thought that soil microbial diversity is a factor in determining disease severity, as the dynamics within a microbial community are known to influence the activity of disease-causing pathogens.

In this project, we seek to increase our knowledge of soil microbial communities in which the proliferation of cotton root pathogens may be promoted or suppressed, and to determine the impact of management practices on soil microbial diversity. This knowledge could ultimately be used to identify management strategies to minimise cotton root diseases. Our research methods include the use of molecular microbiology techniques and community level physiological profiling to characterise and quantify soil microbial communities. In the first four months of the project we have commenced an initial greenhouse trial to determine whether or not disease suppressiveness can be induced in a soil by transferring microbial populations from a soil known to be suppressive. We have also commenced work on the optimisation of experimental conditions for the molecular microbiology procedures that will be used with our soils. Our first in-field testing will start in October with the next growing season.

Project Number: 3.1.15 AC

Using Satellite Digital Data and Other Exogenous Features for Improving the Inventory of Cotton Soil

AIMS AND MILESTONES

Aims and milestones of this project are to:

- produce maps of the study area, including soil attribute maps and soil type maps
- use soil property variability to provide information for areas of risk in sustainable cotton production
- add the soil information and areas of risk to the GIS of the cotton growing regions
- complete the writing of a PhD thesis by the end of 2001.

STAFF

Dr I.O.A. Odeh, University of Sydney
Marian Dunbar, PhD Student, University of Sydney

PROGRESS

Soil information is required in the cotton industry to help in decision making processes of land management and to provide information on land quality. To produce this information at a scale large enough and accurate enough to use can be time consuming and costly. At present there are large amounts of satellite information readily available, and this data can provide some information about the soil. The advantage of using satellite data is that it is at a resolution that cannot be collected in a soil survey, but the disadvantage is that vegetation cover hides the reflectance of the soil. If the vegetation cover can be filtered from the image, there is the opportunity for more accurate prediction of soil attributes, in association with the satellite data, than previously available.

The main aim of this project is to filter the vegetation from the satellite images and to make predictions of the soil properties that indicate the quality of the soil. A Landsat-TM image has been filtered, and this has created a new set of derivatives that can be used to help predict soil attributes. Some of these derivatives have a higher correlation with soil properties than the original bands. These derivatives were then used in multiple linear regressions to improve the accuracy of the regression. This, in turn, has produced soil attribute maps that have a better accuracy than those produced without the filtered derivatives. The maps that are produced will be added to the GIS (Geographical Information System) of the cotton growing regions and be readily available to growers and decision-makers.

Project Number: 3.1.17AC

Physiological and Agronomic Factors Affecting the Efficacy of Bt in Transgenic Cotton

AIM AND MILESTONES

The aim of the project is to assess agronomic factors influencing the efficacy of INGARD cotton.

Milestones in Year 1 (2000-2001) were to do the following:

1. Establish different management regimes (sowing date, fertiliser rates) and physiological treatments (waterlogging, water stress, boll load) on one or two gene cotton varieties.
2. Set up studies on temperature and daylength in phytotron.
3. Determine Bt expression using bioassays and quantitative assays (carried out at the station using equipment that Dr G Fitt has requested). Some more work is required on the quantitative assay (Dr Helen Holt), which may result in modifications to the technique in the 2000-2001 season.

STAFF

Dr Ian Rochester, CSIRO Plant Industry, Narrabri
Mrs Jenny Roberts, CSIRO Plant Industry, Narrabri (appointed in January 2001)

PROGRESS

The cotton industry sees INGARD cotton as the basis for reducing the economic burden of *Helicoverpa* control and the environmental consequences of insecticidal sprays. Variability of performance among INGARD crops makes these objectives more difficult to achieve. This work will address the possible role of agronomic factors in variable performance of crops.

Technology is now available to assess the concentration of Bt protein in plant tissues with the aid of commercially available quantitative Bt ELISAs. This approach enables 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 sodicity will be evaluated.

The outcomes of 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.

The experiments conducted over the past six months indicate that cotton cultivars and crop planting density can have a profound influence on levels of Bt assayed in leaf tissues, but nitrogen management and application of growth regulators appear to have only small effects.

Project Number: 1.2.4

Development of Pedotransfer Functions to Predict Hydraulic Properties of Cotton Growing Soil in Eastern Australia

AIMS AND MILESTONES

The aims of this project are to:

- establish water retention, conductivity and shrinkage relationships for cotton growing soils in four geographical regions and use this as a prediction data set
- develop pedotransfer functions to predict these hydraulic relationships from more basic soil properties
- verify the developed functions against data from an on site drainage experiment and literature data (the verification data set) using a simple numerical model.

Milestones were as follows:

1. *July 1999*. Sampling of first half of 20 sites completed, physical and chemical analyses in the laboratory commenced.
2. *December 1999*. Structure analysis commenced, physical and chemical analyses ongoing.
3. *July 2000*. Sampling of all sites completed. Physical and chemical analyses on first half of sites completed. Structure analyses on half of sites completed. Analysis of data commenced. On site drainage experiment completed.
4. *December 2000*. Physical, chemical and structure analysis completed. Analysis of data completed, leading to the development of pedotransfer functions.

STAFF

Dr S.R. Cattle, Lecturer in Soil Science, University of Sydney
Dr R. W. Vervoort, McCaughey Lecturer in Hydrology and Catchment Management, University of Sydney
Dr B. Minasny, Research Associate, University of Sydney

PROGRESS

This project is in the final stages and reaching completion. All field and laboratory data have been collected with the exception of a few of the still troublesome and slow soil-water characteristics. The data set, consisting of the hydraulic, physical, chemical and mineralogical characteristics of 21 Vertosols, has been collected in a Microsoft®Access database and combined with the structural form data derived using *Solicon*. The database or extractions of specific data are freely available by contacting the Dr R.W. Vervoort (e-mail w.vervoort@acss.usyd.edu.au). This database is very basic, but includes all the gathered data in tables combined with an overview of the basic relationships. We are currently working on making the database available through the Internet. We have chosen the "basic data" approach to allow each user to develop his or her own queries and relationships. Some standard relationships have been fitted to the data, in particular to the hydraulic data, and tables of the fitting parameters have been included. However, by adopting the "basic data" format, the user is free to redo the fitting procedure or use different relationships to describe the data.

Analysis of the data has indicated some interesting relationships. Most of the measured saturated hydraulic conductivities were high (mean: 210 mm/hr), indicating a high potential for water intake and possible drainage. However, one of the other main features of the hydraulic conductivity data was the sharp decrease in hydraulic conductivity with supply potential. A slight decrease of saturation (from saturated to 1.5 kPa) caused a drop in hydraulic conductivity of two orders of magnitude. This indicates the potential for achieving low drainage rates if the soil is kept unsaturated under irrigation, but could also indicate the potential for high runoff under rainfall.

The strongest factor in determining the hydraulic properties was whether the investigated site was a topsoil (top 20 cm) or a subsoil (below 40 cm). In fact the hydraulic conduc-

tivity decreased two orders of magnitude below 40 cm depth on the two sites where the subsoil was sampled. This might have been due to the management factors at the locations, which were measured but, more importantly, highlights the effect of overburden pressure on the hydraulic conductivity relationship. The depth factor dominated trends in bulk density, hydraulic conductivity and many of the chemical and physical properties such as exchangeable sodium percentage (ESP), and the fine clay fraction (<0.2 μm). These factors can be useful in predicting hydraulic properties if the depth of the sample is included in the relationship. None of the other basic chemical and physical data indicated any strong relationship with the hydraulic properties. In fact, the best single predictor of the hydraulic conductivity was the field bulk density, measured on clods (r^2=0.56). However, using multi-linear regression, and including depth as a predictive parameter, revealed more complex combinations. These analyses indicated a strong influence of exchangeable Ca and the clay fraction, followed by possibly bicarbonate P, $CaCO_3$ and EC 1:5 in water, on the hydraulic conductivity. The effect of the bicarbonate extractable P is interesting, indicating a possible relationship with either mineralogy or general fertility status. Shrink-swell parameters, such as the slope of the basic shrinkage phase were more dominated by clay content and exchangeable Mg values, followed by $CaCO_3$ and dithionite Fe.

Structural form influenced the hydraulic conductivity, so that the hydraulic conductivity decreased as the mean size of the structural elements increased. Again the depth of sampling had an overriding influence on this relationship, indicating a much denser structure in the subsoil compared to the topsoil. The information gathered with the soil structural analysis can, with some manipulation, be used to predict hydraulic properties, but the efficiency of this approach is doubtful. It is much more time consuming and difficult to gather the soil structural form data, then soil hydraulic properties. The major advantage of the structural form data is the high level of information contained in each sample and the fact that most of the analysis can be done in the laboratory and on the computer. The structural form parameters were again clearly dominated by the increase in ESP and exchangeable Na with depth, corresponding with increases in MSIL and decreases in porosity. But the actual relationship between cause and effect is, however, unclear because of to the influence of overburden pressure. More work would need to be done on influence of overburden and depth relationships of soil physical and chemical properties in these soils.

The pedotransfer functions are being developed using a new neural network approach, which predicts parameters of the van Genuchten water retention function. This approach can predict water content 15% more accurately compared with conventional neural networks. This is documented in a paper submitted to the *Soil Science Society of America Journal* (Minasny and McBratney, 2001). These pedotransfer functions will be incorporated in the model to be developed for Project 3.2.8, "Hydrologic modelling for sustainable irrigation management practices in cotton production".

Project Numbers: 3.2.0 AC, 3.2.3 AC, 3.2.4 AC, 3.2.5 AC

Understanding the Salinity Threat in the Irrigated Cotton Growing Areas of Australia – Phase III – Implementation and Management

AIMS AND MILESTONES

The aims of the projects are as follows:

- Apply Mobile Electromagnetic Sensing System (MESS) to determine usefulness in:
  a. identifying factors and management in areas experiencing soil salinity
  b. identifying potential application of gypsum and lime to ameliorate sodic fields
  c. identifying areas of water use inefficiencies near dams and channels.
- Conduct EM34 surveys to describe distribution of EC_a that can be related to:
  a) areas where shallow or deeper saline watertables are suspected
  b) where excessive deep drainage or groundwater recharge may be occurring.
- Coordinate and ensure there is collaboration between the various projects where soil and water research is occurring in the irrigated cotton growing areas.

Milestones for 2000-2001 were:

Salinity assessment

1. MESS will be used to generate information on the spatial distribution of soil EC_a on the field scale.

Sodicity assessment

1. Assessing the usefulness of the MESS in generating information to assist in strategic application of gypsum and lime in a field where high SRA water has been used over a prolonged period of time.

Water use efficiency

1. MESS will be used to provide an indication as to where excessive deep drainage may be a problem.
2. Using collected data, along with a large number of soil samples and measurements on distribution uniformity, the causes of shallow watertables and soil salinity should be elucidated.
3. Collected data along with some detailed soil physical measurements, including infiltration of water, will be carried out to detect differences and consequences of various management practices.

STAFF

Dr John Triantafilis, Senior Research Scientist, University of Sydney
Mr Faruque Ahmed, Masters Student, University of Sydney
Mr Andrew Huckel, Masters Student, University of Sydney
Dr Raj Malik, University of Sydney
Mr Michael Short, University of Sydney

PROGRESS

1. Field scale

a) A MESS survey was undertaken on Cumberdeen field 4 (lower Namoi Valley) to identify causal factors and possible management options in areas experiencing soil salinity. Laboratory analysis has been completed and the results suggest the area where the storage is leaking is due to better structured soil. Management options have been recommended.

b) Similarly, a MESS survey was undertaken on field 10 at Warianna (lower Namoi Valley) to identify areas that require gypsum or lime or both to ameliorate sodic soil condition. Laboratory analysis of soil and water samples has been completed. Interpretation of the data is continuing.

2. Multiple-farm scale

a) **Darling River Valley – southwest of Bourke.** An EM34 survey consisting of 593 measurements was carried out on a 500 m grid. Soil samples to a depth of 15 m were drilled at fifty locations. Laboratory analysis of samples completed to date includes soil salinity and pH. Clay content and cation exchange capacity will also be determined. Depth of watertable and salts present will also be determined.

b) **Macintyre Valley – southeast of Toobeah.** An EM34 survey has been completed and includes over nine hundred measurements located on an approximate 500 to 1000 m grid. Soil samples will be drilled at 40 to 50 locations to depths of up to fifteen metres. Some of these will be paired to enable a comparison between irrigated and native fields for determination of groundwater recharge rate.

c) **Gwydir Valley – northwest of Moree.** An EM34 survey was completed and includes 873 measurements. Soil samples were drilled at a hundred locations to a depth of 1 m. Samples were analysed for clay content and cation exchange capacity. These were entered into a salt and leaching fraction model to estimate deep drainage. Results suggest that improvements in water storage location may improve water use efficiency.

d) **Lower Namoi Valley – centred around Wee Waa.** An EM34 survey was carried out on a 1000 m grid. In all 1,868 sites were visited in 1999. Thirty six holes have been drilled to determine the groundwater recharge rate using a simple chloride mass balance model.

e) **Upper Namoi Valley – southeast of Gunnedah.** An EM34 survey was carried out on a 500 to 1000 m grid. In all 867 sites were visited. Soil samples will be collected initially to a depth of 2 m and used to model the impact of applying increasingly saline water.

f) **Macquarie Valley – southeast of Trangie.** An EM34 survey has been completed and includes 723 measurements located on an approximate 500 metre grid. Soil samples at forty locations have been drilled to depths of up to 15 m to assist in interpreting survey results. Samples have been analysed for pH, clay content, soil salinity and cation exchange capacity. Interpretation of results is in progress.

g) **Macquarie Valley – southeast of Warren.** An EM34 survey is planned and is due to begin in July 2001. Soil samples at forty locations have been drilled to depths of up to 15 m to assist in interpreting survey results. Samples have been analysed for pH, clay content, soil salinity and cation exchange capacity. Interpretation of results is in progress.

3. Collaborative links

a) Researchers collaborative links have been established with are: Janelle Montgomery (CRC-University of New England), Dr Inakwu Odeh (CRC-University of Sydney) and Dr Stephen Raine (CRDC-University of Southern Queensland).

b) Links have also been established with the following community groups: Macintyre River Valley Water Users Association (Bruce McCollum); Gwydir Valley Irrigators Association (Wal Murray); Coordinating Committee of Namoi Valley Water Users (Jerry Killen), Upper Namoi Cotton Growers Association (Mark Hickman); Macquarie 2100 (Adam Collings); and Bourke Irrigators Association (Tony Thompson).

Project Number: 3.2.1 AC

Development of an Integrated System for Remediation of Waterborne Pesticide Residues in Cotton Farms

AIMS AND MILESTONES

The aims of the project are to:

- design, construct, trial and assess the performance of an integrated system for waterborne pesticide treatment on farm
- transfer this pilot system to a larger scale treatment of stormwater runoff at the farm outlets, thus preventing contamination of the riverine environment with pesticide residues from agricultural practices.

Milestones were:

1. Year 1. Assess influent parameters (irrigation and stormwater) to enable pilot design. Trial and assessment of plant species for efficacy in removal and resistance to herbicides. Laboratory biodegradation trials. Literature reviews on plants, biodegradation and adsorption.
2. Year 2. Design and construct pilot scale trial on one site for stages 1 and 2, and possibly 3. Assess performance of pilot trial, including the necessity or otherwise of adsorption. Continue biodegradation trials if necessary.
3. Year 3. Refine and remodel design on first site after results of previous year. Construct second pilot; include adsorption (Stage 4) if necessary. Reassess environmental and economic performance.

STAFF

Ivan R. Kennedy, Professor in Agricultural and Environmental Chemistry, University of Sydney
Dr Francisco Sánchez-Bayo, Research Associate, University of Sydney
Michael Rose, 4th year student, University of Sydney

PROGRESS

Because of late notification of funding by the National Heritage Trust (late November 2000) it was not possible to carry out research activity in the 2000-2001 cotton season. However, activity since January 2001 includes the following:

- A thorough literature search on field bioremediation studies (only 23 publications found). This has provided methods for field and laboratory trials. Very few of these studies dealt with pesticides, most of them being mainly concerned with heavy metals.
- About thirty native wetland plant species considered beneficial in ecosystems have been selected for this study from a database of more than 100 species, weeds and noxious plants being excluded. Six of these species, taken from the Macquarie Marshes, have been grown satisfactorily in a greenhouse after transport to Sydney and are currently being used in laboratory trials with pesticides.
- A *Rhodococcus* strain capable of degrading triazine herbicides to be used in laboratory tests after the plant degrading trials, was obtained from NSW Agriculture laboratories at Wollongbar.
- Methods for the analysis of initial selected pesticides (endosulfan, profenofos, chlopyrifos, dimethoate, aldicarb, diuron, fluometuron, prometryn, metolachlor) have been obtained from the literature and tried out in our laboratory. ELISA will be used as an analytical tool for endosulfan, chlorpyrifos and diuron degradation in these studies.

- Laboratory trials involving three plant species (common watermilfoil, slender knotweed and water primrose) have been conducted to date. Each trial was followed by a second degrading experiment with *Rhodococcus* with the aim of eliminating any remaining pesticide residues not degraded by the plants tested. Below are some comments on these laboratory trials.
- A site for a field trial has been found and will be inspected for farm works in June 2001 and we expect to carry them out during the coming months before the next cotton season starts.

With a reduction in funding we decided to focus on five of the initial nine selected pesticides: the insecticides endosulfan, chlorpyrifos and aldicarb, and the herbicides fluometuron and prometryn. This ensures that the original project objectives of testing a wide range of plant species and conducting two field pilot trials over 2 years still hold.

Each laboratory trial involves testing the ability of a plant species to degrade the chosen five pesticides. Several plants are placed in a 20 L hydroponic solution contained in stainless-steel laundry tubs (45 L capacity). The solution is spiked with known amounts of each pesticide in the levels predicted to occur in runoff waters from cotton fields. The tubs are exposed to natural light inside a glasshouse for three weeks, with regular sampling of 500 mL of solution for pesticide analysis every week plus an additional sampling at the beginning of the experiment. Three replicates and a control (no plants, only spiked solution) are set up in each trial. After three weeks all plants are removed and homogenised for pesticide residue analysis, but the solution is kept for the second degrading experiment using *Rhodococcus*, which are introduced by adding equal number of prepared beads to each treatment tub. Sampling of equal amounts of solution for pesticide analysis is done every three days for 2 weeks.

Water samples are currently being analysed in our laboratory using HPLC for aldicarb, fluometuron and prometryn and ELISA for endosulfan and chlorpyrifos. Partial results indicate that both herbicides are left untouched by the plants whereas some degradation of aldicarb and the other insecticides is apparent. Results from the microbial stage are still pending. The full data set of these initial laboratory trials are to be completed by the end of June, and results will be presented to the annual CRC meeting in July.

This work fulfils the milestones for Year 1 of the project except for the assessment of effluent parameters on farm, which is still pending and will be done this winter season. The latter assessment is necessary for the design of the field pilot trials on a specific farm site, to be constructed in the oncoming months. However, because of a late start more laboratory trials using different plant species are still needed, and these are scheduled for the next few months until the pilot field experiments start. In this regard, Pacific Azolla, duckweed and spike rush are currently being grown in the glasshouse waiting to be tested and more species will be collected in the next few months for the same purpose. The aim of testing a wide range of plants is to select those with the highest degrading ability that would be used in the pilot field trials next year.

Project Number: 3.2.2AC(a) and 3.2.2AC(b)

Economic Value of Ecosystem Services Underpinning the Gwydir Valleys Cotton Industry

AIMS AND 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.

Milestones of the project are as follows:

1. *(December 1999: Production of ecosystem functions and services classification - national step 1.)*
2. *(February 2000: Production of framework for ecosystem accounting in Australia.)*
3. *(February 2000: Assessment of services and valuations of selected types.)*
4. July 2000. Form expert reference group for the Gwydir study.
5. September 2000. Assessment of ecosystem services and valuations to be considered in the Gwydir study in conjunction with the national project.
6. October 2000. Completion of research plans for desktop, field, modelling and economic studies in the Gwydir study in conjunction with the national project.
7. June 2001. First annual report to Cotton CRC, describing the results of the desktop studies, first season's fieldwork, and preliminary modelling.
8. September 2001. Completion of research plans for further desktop, field, modelling and economic studies.
9. *(March 2002: Finalisation of biophysical and socio-economic models and outputs for each CSIRO-Myer case study.)*
10. June 2002. Second annual report to Cotton CRC, describing the final results of the desktop studies, the second season's fieldwork, and advanced modelling results.
11. *(October 2002: Synthesis - policy implications and critical review of national study)* March 2003. Final report on policy and management implications of the study. *(May 2003: National project's international symposium on The Nature and Value of Ecosystem Services.)*
12. June 2003. Launch of extension booklet and media releases on study's findings and implications. Final report to Cotton CRC.

[Italicised milestones in brackets refer to the CSIRO-Myer national project (Anon. 1999), with which this project is affiliated.]

STAFF

Associate Professor Nick Reid, University of New England
Dr Letitia Silberbauer, Postdoctoral Fellow, University of New England
Mr David Thompson, Principal, Centre for Agricultural and Regional Economics

Collaborators

Dr Ian Oliver, Research Scientist, NSW Department of Land and Water Conservation
Dr Ken Hodgkinson, Senior Principal Research Scientist, CSIRO Sustainable Ecosystems, Canberra

PROGRESS

What are ecosystem services?

Our working definition of 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 fall into three broad categories:

1. those that produce goods
2. those that break down waste products
3. those that maintain natural assets.

"Goods" can include food and fibre, as well as less tangible products like life fulfilment values.

Ecosystem services derive from ecological processes. Examples of ecosystem services in rural catchments include the provision of adequate amounts of clean 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.

Why should we care?

Ecosystem services are important because, although they are often free, they are not immune to human mismanagement. Unfortunately, we have sometimes failed to recognise and value ecosystem services sufficiently and have inadvertently damaged them. Given the cost of rehabilitation, recognition of the damage done after the event is often too late. There is also growing consumer pressure for goods to be produced by sustainable production systems, and this will be increasingly important for market access in the future.

Aims of project

The aims of this project are to publicise the nature and importance of ecosystem services among the Gwydir community, and to seek the community's assistance in identifying and prioritising the most important ecosystem services to them. We then wish to value management-induced changes in the provision and impact of the most important ecosystem services at both a farm and regional scale. We are looking to the Gwydir community, as well as the scientific community and our stakeholders, to guide us in selecting appropriate ecosystem services, and in developing the most appropriate scenarios of land use change and changes to farm practices to investigate.

Project growth

Since the beginning of this project in January 2001, the scope of the research has grown to include the entire Gwydir catchment, with sub-projects being developed with collaborators to focus on upper and middle catchment ecosystem services, as well as the lower catchment cotton sub-project. The growth of the Gwydir ecosystem services project has included close collaboration with a range of other research agencies. Our research team now includes Dr Ian Oliver and Dr Brian Wilson (both from NSW Department of Land and Water Conservation, Ecosystem Processes and Biodiversity Unit) and Dr Ken Hodgkinson (CSIRO Sustainable Ecosystems). We have also established good communication with the Gwydir Catchment Management Board and representatives of many of the community groups active within the Gwydir catchment.

Project Number: 3.2.6AC

The Environmental Impact of Irrigation in the Gwydir Valley on the Murray-Darling Basin

AIMS AND MILESTONES

The aims of this project are to:

- measure water quality upstream, within and downstream of the Gwydir Irrigation Area
- measure the quality of water onfarm
- combine water quality data with river flow data to determine inputs of salts and nutrients along the Gwydir Valley watercourses to establish the Gwydir Valley's input to the Murray-Darling Basin
- demonstrate inexpensive Electromagnetic (EM) methods to assess irrigation inefficiencies at a multi-farm level
- demonstrate inexpensive EM methods to identify shallow groundwater levels at a multi-farm level
- assess the provision, by onfarm storages in the Lower Gwydir Valley, of resources that support wetland bird species, feeding, breeding, growth and migratory habits
- collate and interpret information for irrigators on options for management of onfarm storages in relation to wetland bird species.

Milestones for the project are as follows:

1. Year 1:
   - set up water sampling sites on watercourses and onfarm that will be linked to soil salinity and birdlife studies
   - collect water samples and analysis for salts and nutrients
   - conduct survey of bird numbers and species and identify key breeding sites.
2. Year 2: Continue monitoring of water quality throughout the Gwydir Valley. Based on results from Year 1, identify areas of poor water quality and select sites for soil salinity surveys. Conduct soils salinity surveys.
3. Year 3: Further monitoring of water quality. Collate results from water quality, soil salinity and birdlife studies. Examine the contribution of irrigation to any environmental problems that are identified. Recommend strategies to reduce any adverse effects of irrigation.

STAFF

Mrs J. Montgomery, Research Fellow, University of New England
Associate Professor R. Faulkner, Project Supervisor, University of New England
Dr J. Triantafilis, Senior Research Scientist, University of Sydney
Professor P. Jarman, Consultant, University of New England

PROGRESS

Irrigators are often accused of causing a deterioration of water quality in the Murray-Darling Basin. For many catchments such as the Gwydir, little reliable information is available to assess the input of irrigation. The main aim of this project is to monitor water quality upstream, within and downstream of the Gwydir Irrigation Area to determine the effect of irrigation. Water quality will be linked to a survey of soil salinisation in irrigated areas using electromagnetic induction methods. The species, breeding and growth of birdlife on on-farm storages will be assessed and related to water flow and quality. The project will provide the basis for applying management strategies to environmental problems identified as being caused by irrigation.

Water sampling started in October 1998 and is continuing until September 2001 from twenty sites above, within and below the Gwydir Irrigation Area. Water samples are also collected from 15 on-farm water storages located throughout the lower Gwydir Valley. The water samples are analysed for a range of physico-chemical, nutrient and

Protecting the health of rivers is a cotton industry priority

salt data, including pH, dissolved oxygen, electrical conductivity, turbidity, suspended, dissolved and total solids, total phosphorus, reactive phosphorus, total nitrogen, nitrate and nitrite, chloride, potassium, calcium, magnesium, sodium and the sodium adsorption ratio, a measure of sodicity. The water quality data will be linked with river flow data to determine inputs of salts and nutrients along the river.

Results of analysis of water quality show that salinity level is medium, sodicity is low, but turbidity is high. Preliminary analysis of nutrient data suggests the waters are nutrient rich. The results show the importance of examining loadings when assessing water quality. Although concentration of salts and nutrients are lowest at the top of the valley, the loads are highest at these sites as the flow is significantly greater compared with sites at the bottom of the valley.

A broadscale EM 34 survey conducted north of Moree was completed in April 2000. Covering an area of about 20 x 20 km, the EM34 was used to characterise the shallow stratigraphy and map the spatial distribution of shallow watertables in the area surveyed to evaluate the extent and risk of salinity in the area. The area surveyed was split into management zones. These are zones of a particular soil type, the presence of a shallow watertable or areas where irrigation inefficiencies may be occurring or both, and therefore need to be managed differently in terms of salinity management.

To assess the provision by on-farm storages of resources that support wetland bird species, feeding, breeding, growth and migratory habits, nineteen on-farm storages with varying degrees of vegetation are surveyed at 3-weekly intervals to record number and species of waterbirds. Environmental variables such as vegetation, water quality and water depths are measured and breeding events recorded. The great majority of waterbirds likely to occur in the lower Gwydir Valley have been recorded on storages, but there are notable absences. Each storage tends to support a characteristic set of species. This confirms that species respond to attributes of a storage and possibly to the presence of other species. Breeding events can be supported by storages, however, water drawdown can terminate the event. The data collected will be used to provide irrigators with options for management of on-farm storages in relation to wetland bird species.

Project Number: 3.2.7 AC

The Effects of Cotton Defoliants on Native Trees from Northwestern NSW – Field-Based Experiments

AIMS AND MILESTONES

The aims of the project are to:

- measure the effects of commercial combinations of cotton defoliants on native tree species under field-based conditions
- measure the effects of repeated annual exposure of cotton defoliants on native tree species
- determine the ability of trees to recover from exposure to defoliants
- measure the difference in effects between different defoliant modes of action (i.e. hormonal-based abscission defoliants and salt-based desiccant defoliants)
- recommend suitable defoliant-tolerant native tree species for use in vegetative buffer strips for both on-farm and off-farm locations
- measure cotton defoliant drift under a range of field conditions during commercial operations
- provide a postgraduate research opportunity in an area that is highly relevant to the cotton industry for ecologically sustainable management.

Project milestones were as follows:

In 2000:

1. Finalise experimental design in consultation with the industry.
2. Choose and establish experimental sites –tree planting must be completed by late autumn.
3. Tend and maintain experimental sites over the year to minimise tree losses.
4. Complete first tree measurements.
5. Measure and report on the levels of cotton defoliation drift under field conditions.

In 2001:

1. Apply cotton defoliants to trees (two applications) at about the same time as the industry.
2. Complete four tree measurements.
3. Measure and report on the levels of cotton defoliation drift under field conditions.
4. Prepare results from the first year of treatment.
5. Maintain experimental sites throughout the year.

STAFF

Adam Downey, PhD Student, University of New England
Dr John Duggin and Mr Guy Roth, University of New England, Armidale
Associate Professor Nick Reid, University of New England, Armidale
Dr Bert Jenkins, Greening Australia, Kentucky St, Armidale
Mr Trevor Stace, University of New England, Armidale

PROGRESS

2000

Decisions concerning the experimental design of experiment's one and two in the project were made in August by project staff and members of the industry. These decisions were about aspects such as the number of native tree species, the type and number of defoliants, the number of treatments, the number of application rates and size of site blocks. These decisions were made to allow the establishment of the experiments as scheduled while other decisions (i.e. actual amounts for rates etc.) were not finalised until early 2001, before the first year application of treatments. This allowed for further thought and consultation with the industry.

John Duggin, Carolyn Johnston, Guy Roth, Robin Watson and Adam Downey tree planting at the Cotton CRC Development Trial, August 2000.

Two field sites were chosen and established in August on the cotton properties "Kilmarnock" and "Milchengowrie" near Boggabri, NSW. The owners of "Kilmarnock", John and Robyn Watson, were keen to host the project as they are actively involved in conservation activities in the district as well as being cotton producers. The Production Manager of "Milchengowrie", Rob Evans, was also happy to provide us with a suitable site.

It was not possible to complete tree planting by late autumn, (the second part of this milestone) because the project started later than planned (late July 2000). Therefore, we aimed at planting during spring, which still provided enough growing time before the 2001 defoliation season. This new aim was achieved as all planting at both sites was completed during September. The sites were maintained regularly after planting to minimise tree mortality and stimulate tree growth. This included watering, slashing and weed control, fencing (netting fence) to control pests such as hares, rabbits and kangaroos, replacement of dead trees and the construction of irrigation systems. Both properties provided excellent in-kind support in terms of watering and all other maintenance, especially fence construction at "Kilmarnock". A drip irrigation system was constructed in October at "Kilmarnock" and used as a prototype to see if the trees could be sufficiently watered. Flooding occurred in the district during November although neither site was actually submerged nor damaged by floodwaters, however, hotter weather followed. This highlighted the need for the irrigation system and showed that it was working as trees were achieving good growth.

First data was collected at both sites in December. Variables measured included total height and the number of lateral branches. These variables were the only ones deemed necessary at this stage of the experiment to simply give an indication of total height and growth rates (i.e. from future measurements).

The milestone regarding reporting on the levels of cotton defoliation drift under field conditions was not achieved for two key reasons. Firstly, because of the start time of the project (i.e. July 2000), it was decided that there was not enough time to effectively carry out experiment 3 in the first year. Secondly, the sites and the methods for experiment 3 had not been defined. It was decided that the experiment would not be started until after the first two experiments had been established (i.e. having tree planting, site maintenance and first year experimental application completed). This means that only two season's worth of data would be collected for experiment 3 instead of three season's worth from experiment's one and two.

2001

The key milestone for 2001 was the application of cotton defoliants to the trees for experiments one and two at around the same time as the industry was applying them. This was achieved, although both applications were postponed because weather conditions were unfavourable. The first application, planned for the week beginning 9 April 2001, was postponed until the following week because of strong winds, which made spraying impossible without the risk of drift between treatments and application rates. This decision was important to the outcomes of the project because under such conditions the drift effect could have biased any results.

It was also important because chemicals applied from the air should not be applied during very windy conditions to avoid any off-target drift. The second and final application for the year was planned for two weeks after the first planned spray, or the week beginning 30 April 2001, which follows defoliation techniques in commercial cotton production (i.e. second defoliation 10 to 14 days after the first). Unfortunately, this had

Mike Fittler, John Duggin, Adam Downey and Guy Roth tree planting at Boggabri, Cotton CRC Development Trial, August 2000.

to be postponed until the next week because of wind and rainfall. The wind represented the same problem relating to drift, while the rainfall was a problem because rain (within 24 hours of application) can reduce the effectiveness of the defoliants to work as intended, which could again affect or bias any results. This meant that treatment applications were carried out slightly later than defoliation would normally occur in commercial cotton production (i.e. late March to mid April). This was not seen as a problem as a "late season" was experienced in the region because of the weather conditions that affected the project. Many cotton producers in the region, including one of our host properties "Milchengowrie", were also late with their defoliation due to the weather and were still defoliating their crops while we were applying defoliants. The late cotton season may have been associated with the hot temperatures during the previous spring and summer and the two periods of flooding (November 2000 and January 2001).

Two of the four tree measurements have been completed. The first tree measurement or data collection period for the year was done during the week beginning 9 April 2001, one week before the first application of defoliants. Variables measured included total height, height growth (calculated from this measurement and the previous measurement) and the number of lateral branches (delineated by upper, middle and lower tree canopies).

The second data collection period was three weeks later during the week beginning 30 April 2001, one week before the second application of defoliants. Extra variables were measured in this data collection period including necrotic spots on leaves, necrotic leaf margins, leaf discolouration, apical growing shoot damage, and defoliation. The third, fourth and any extra measurements will be completed at regular intervals throughout the remainder of the year.

The milestone involving measuring and reporting on cotton defoliation drift under field conditions has not been achieved for the same reasons as mentioned for the same milestone for 2000. Methods for experiment 3 are now a major priority of the project so that the experiment can be established for the 2002 defoliation season. Preparation of results from the first year have not been completed yet, although initial data analysis of data collected has started. This milestone can only be achieved later in the year, as much of the data for the year have not been collected.

Maintenance of the experimental sites is an ongoing commitment necessary for the success of the project and is being done regularly. This has involved the completion of the fence around the site at "Milchengowrie", weed control including slashing with a tractor, brush-cutters and manual weeding, maintenance of the watering system and monitoring of hare/rabbit damage to trees. Any other maintenance will be carried out when necessary throughout the year in order to keep the sites tidy and workable for a successful project.

Project Number: 3.2.8 AC

Hydrologic Modelling for Sustainable Irrigation Management Practices in Cotton Production

AIMS AND MILESTONES

Aims and milestones for this project are to:

- develop a toolkit for predicting soil hydraulic properties (e.g. DUL, LL) from basic soil properties
- develop a soil-water routine for shrink-swell soils
- compile and research model routines needed for the hydrological model
- develop an outline of the full hydrological model, detailing the subroutines and how each component interacts.

STAFF

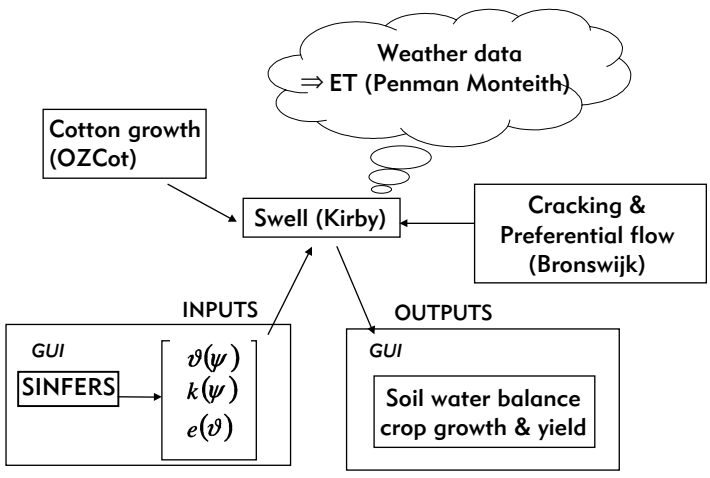
Dr Willem Vervoort, University of Sydney
Dr Stephen Cattle, University of Sydney
Dr Budiman Minasny, Research Fellow, University of Sydney

PROGRESS

We have developed a concept of soil inference systems, which will be implemented as a toolkit for predicting soil hydraulic properties. While much current research focuses on the development of new functions for predicting soil physical and chemical properties for different geographical areas or groups of soil types, there seems to be little effort to define the uncertainty of the prediction and use this information as a tool for decision-making. Pedotransfer functions are mainly used in terms of *data* translation. If we describe this translation function as *information*, and this information when properly and logically conjoined constitutes *knowledge*. Knowledge can generate various data. The soil inference system takes measurements we know with a certain precision and infers properties we don't know with given precision, by means of properly and logically conjoined pedotransfer functions. We call this the soil inference systems (SINFERS), where pedotransfer functions are the knowledge rules for inference engines. This approach allows all kinds of uncertainty to be treated in a logically consistent way.

This new concept will be implemented in user-friendly software with proper graphical user interface (GUI). The program will ask questions such as "What soil properties do you have?" and will give output of soil hydraulic properties along with their uncertainties.

Figure 8. Routines for the cotton hydrologic model.



For the soil-water-plant model in the swelling soils, we have identified and are working towards a complete model (Figure 8), which comprises:

1. water movement in a shrink-swell soil (SWELL), which is numerical solution of Richards' equation based on material coordinate systems
2. preferential flow and soil shrinkage according to the theory proposed by Bronswijk
3. evapotranspiration, based on climatic data using the Penman-Monteith method, with an option for using the Bowen ratio
4. cotton growth model, which hopefully can be based on the existing Cotton CRC model *OZCOT*.

The soil-water routines for swelling soil have been acquired from Dr Mac Kirby, CSIRO Land and Water. The evapotranspiration calculation has been written and the preferential flow model is currently being written.

The complete model will have an interface which is a soil inference system requesting the basic information from the user. It will predict the soil hydraulic properties along with their uncertainties. The hydraulic properties will be used by the soil-water-plant model to predict water balance and plant growth. This will be presented in an interactive graphical output.

Project Number: 3.2.9 AC

Enhancing the Impact of Early Season Predators on *Helicoverpa* Spp.

AIMS AND MILESTONES

The aims of this project are to:

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

Project milestones were as follows:

1. Finalise development of ELISA technique for a range of coccinellid species and begin development for other species.
2. Set up initial experiments to quantify the effects of individual predator species or groups of species.

STAFF

Dr Sarah Mansfield, Post-doctoral Fellow, CSIRO Entomology
Judy Nobilo, Technical Assistant, CSIRO Entomology
Dr G. H. Baker, Senior Principal Research Scientist, CSIRO Entomology
Dr L. J. Wilson, Principal Research Scientist, CSIRO Plant Industry

Collaborators

Dr S. Trowell, (CSIRO Entomology), Dr A. Reddall (CSIRO Plant Industry), Dr R. Mensah (NSW Agriculture), Dr Mr L. Johnson (University of Queensland), Dr J.R. Hagler (USDA-ARS, Phoenix, AZ).

PROGRESS

Work on this project began late in the season because Dr Mansfield did not take up the position until 16 January 2001. Attempts to rear four *coccinellid* species (*Coccinella transversalis, Coelophora inaequalis, Harmonia octomaculata* and *Micraspis frenata*) on

an artificial diet proved unsuccessful. However, an aphid colony (*Aphis gossypii*) has been established in collaboration with Dr Amelia Reddall (CSIRO Plant Industry) to maintain a colony of three-banded ladybirds, *H. octomaculata*.

Laboratory experiments have been initiated to determine consumption rates of *Helicoverpa armigera* eggs and larvae when presented alone and in the presence of alternate prey (aphids) for the four species of *coccinellids* listed above. Glasshouse experiments have been started to investigate the effects of predator density and alternate prey on *H. armigera* egg consumption by *H. octomaculata*. This species is being studied first because preliminary results suggest *H. octomaculata* consume more *H. armigera* eggs and larvae than the other *coccinellid* species. Both laboratory and glasshouse experiments will continue over winter and into the next growing season when more *coccinellids* can be collected from the field.

Development of the ELISA technique to detect *H. armigera* protein in predators continues, initially focussing on refining the technique developed by Dr Lytton-Hitchins, with the assistance of Drs Stephen Trowell (CSIRO Entomology), Marie-Louise Johnson (UQ) and James Hagler (USDA-ARS). Initial tests of the protocol developed by Dr Lytton-Hitchins indicate an effective detection period of about 4 hours after consumption. A literature review of relevant ELISA methods has suggested possible improvements to the initial protocol and these are being tested. All *coccinellids* used for laboratory tests of *H. armigera* consumption have been frozen as validation specimens for future ELISA tests. Additional *coccinellids* collected from the field were fed *H. armigera* eggs or larvae, held for 0 to 24 hours after prey consumption then frozen. These specimens will be used to establish the effect of digestion time on detection of *H. armigera* antibodies and to further refine the ELISA technique. When the most effective protocol has been developed this technique will be used to measure predation on *H. armigera* in the field. In future, the ELISA methodology will be tested and modified for use with other predator groups such as predatory hemipterans.

Program Four

Education and Training

INTRODUCTION

Improving the skills base of growers, consultants, and research and extension staff working in the cotton industry is essential if the industry is to grow and survive into the future. New technologies for land and crop management are being developed every year. To keep pace with this change, effective educational and training programs need to be in place.

The Australian Cotton CRC's success in developing national training programs is well recognised. The CRC's Cotton Production Course (certificate and postgraduate certificate level) was recognised for its excellence by winning the Business and Higher Education Round Table (BHERT) award for Collaborative Education. The award recognised the level of collaboration reflected in the production and delivery of the course with most of the CRC research organisations involved and some thirty researchers participating in lectures. The CRC will also run new specialised grower training in IPM systems in 2001 and, in collaboration with NSW Agriculture, the WaterWise program is soon to develop accredited training in water management. In collaboration with CRDC and Cotton Australia future training programs may be developed in Environmental Management Systems (EMS).

Training a new generation of researchers is a key aim of the CRC with a strong focus on postgraduate students involved in projects across the CRC programs. Postgraduate training is complemented by our summer scholarship program which provides the opportunity for undergraduate students studying relevant disciplines to work with researchers and extension staff of the Cotton CRC. Education and training is further enhanced by an active scientific exchange program, which facilitates linkages with international institutions and career development for Australian cotton researchers.

AIMS AND OBJECTIVES

The aims and objectives of Program Four are as follows:

- 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 in IPM and BMP
- encouragement of high quality undergraduates to remain in agriculture through undergraduate and summer scholarships
- coordinated exchange program for industry researchers, extension officers and consultants operating within strong international networks.

HIGHLIGHTS AND ACHIEVEMENTS AGAINST MILESTONES

Cotton Production Course

Over the past year our highly successful cotton course has been upgraded to a four-unit structure with a final unit, "Cotton Production Systems", focussed on putting into practice what has been learnt in the other three units.

The number of new enrolments and graduates for both the postgraduate and certificate course continues to grow and the course is now growing in popularity as an undergraduate elective, "Applied Cotton Production", with over 60 students enrolled from five universities.

The course is also endorsed by the Cotton Consultants Association of Australia as an essential training program for new consultants entering the industry. Over 50% of course graduates have been farm agronomists or consultants.

Cotton tour of UNE undergraduates 2001 at Chris Humphries' property.

Specialised short courses

The first IPM short course will be an important step in increasing the skill base of growers and farm managers, particularly at a time when the industry is expanding its adoption of IPM guidelines and areawide management strategies.

The course will focus on insect pests and links strongly with the Best Management Practice (BMP) Program coordinated by Cotton Australia and CRDC. Over two hundred growers are expected to have completed the course by the end of 2002.

The CRC Water Management Program will target the development of an accredited training course in water management in 2001. The course outline will follow on from training programs developed by NSW Agriculture.

Postgraduate Scholarships

Postgraduate scholarships form a critical component of the CRC research program. A number of postgraduates are nearing completion of theses started in the previous CRC. In addition we are recruiting a new group of postgraduates as part of our commitment to train a minimum of 12 new researchers for the future. The exceptional training received by students in a CRC environment has been noted by many of them. Key elements are scientific excellence, working as a part of research teams and close exposure to the real world of industry. Table 4 outlines the full complement of CRC students and indicates the breadth of topics now being researched.

Summer scholarships

The summer scholarship program proved highly successful during the 2000-2001 cotton season with five students completing a diverse range of projects. These included:

- association of plant volatiles with food rewards by *Heliocoverpa armigera* moths
- quantification of *Heliocoverpa armigera* egg dispersion
- parasitoids of cotton aphid in Queensland
- egg parasitoids of *Heliocoverpa* at Byee
- environmental monitoring techniques for farm sustainability (this project didn't start).

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 and a visit to Australia during 2000-2001, as follows:

- XXI International Congress of Entomology, Brazil and a study visit to the USA related to area-wide management, trap cropping, resistance and modelling - Martin Dillon
- XXI International Congress of Entomology, Brazil – Jonathan Holloway
- USA visit to study area wide management of pests in southern USA – Melina Miles
- 2000 AATCC International Conference and Exhibition, USA – Jackie Cai
- Dr Tom Lei sponsored Dr Mitsutoshi Kitao a research scientist from Sappora Japan to Australia.

LINKAGES

Educational links have been expanded to include the University of Queensland, University of Western Sydney and Orange Agricultural College. Strong links have been maintained with Cotton Consultants Australia and the industry's BMP program.

Table 4. Cotton CRC Post Graduate Students

Student	Degree	Commencement Date	Research Project Title/Thesis	University	Supervisors	Org	Funding	Current Status
Becerra Lopez-Lavalle, Augusto	PhD	1 March 1997	Molecular genetic markers for accelerated selection of fusarium wilt resistant cotton cultivars - Project 3.2.4	USYD	Dr Bruce Lyon	USYD	Cotton CRC	In the process of writing up, due to submit mid 2001.
Boydell, Broughton	PhD	1 March 1997	The applications of precision Agriculture techniques to cotton farming systems - Project 5.2.1	USYD	Prof Alex McBratney Dr Greg Constable	USYD CSIRO	Cotton CRC	Due to submit March 2001.
Cook, Allison	PhD	1 March 1998	Genetic marker systems for molecular breeding of cotton cultivars with enhanced resistance to fungal wilt disease - Project 3.2.7	USYD	Dr Bruce Lyon Dr Danny Llewellyn	USYD CSIRO	Cotton CRC	Continuing research, due to submit end of 2001.
Dorahy, Chris	PhD	7 September 1997	Phosphorus nutrition of cotton - Project 5.3.1	UNE	Mr Ian Rochester A/Prof Graeme Blair	CSIRO UNE	Cotton CRC	Due to submit March 2001.
Montgomery, Janelle	PhD	21 August 1995	Water Application and Hydrology	UNE	A/Prof Don MacLeod Dr Richard Faulkner	UNE UNE	Cotton CRC	Due to submit end 2001 - currently undertaking a project for the Cotton CRC.
Kvedaras, Olivia	PhD	1 July 1997	Mating behaviour in Helicoverpa armigera : influence of host plants - Project 2.2.13	UNE	A/Prof Peter Gregg	UNE	Cotton CRC	Due to submit December 2000.
Rungis, Dainis	PhD	1 March 1997	Development of molecular marker technologies in cotton - Project 3.2.5	USYD	Dr Elizabeth Dennis Dr Danny Llewellyn Dr Bruce Lyon	CSIRO CSIRO USYD	Cotton CRC	Due to submit March 2001.
Stiller, Warwick	PhD	1 January 1995	Improving water use efficiency of cotton	USYD	Dr Greg Constable Dr Lyndsay O'Brien Dr Bruce Sutton	CSIRO USYD USYD	Cotton CRC	Submitted mid 2000 - currently employed by CSIRO in plant breeding.
Ahmed, Mohammed Faruque	Masters of Science in Agriculture	March 1997	Understanding the salinity threat in cotton growing areas of Australia Phase III - implementation and management - Project 3.2.0 AC	USYD	Prof. A McBratney Dr John Triantafilis Dr I Odeh	USYD USYD USYD	Cotton CRC	Due to submit March 2001
Huckel, Andrew	Masters of Science in Agriculture	March 1997	Understanding the salinity threat in cotton growing areas of Australia Phase III - implementation and management - Project 3.2.0 AC	USYD	Prof. A McBratney Dr John Triantafilis Dr I Odeh	USYD USYD USYD	Cotton CRC	Due to submit March 2001
Kokkoris, Esta	Masters of Science in Agriculture	March 1999	Understanding the salinity threat in cotton growing areas of Australia Phase III - implementation and management - Project 3.2.0 AC	USYD	Prof. A McBratney Dr John Triantafilis Dr I Odeh	USYD USYD USYD	Cotton CRC	Due to submit March 2002
Crossan, Angus	PhD	March 1997	Development of standard environmental tests for herbicides needed in cotton production - Project 1.1.5	USYD	Prof. Ivan Kennedy Dr Robert Caldwell	USYD USYD	CRDC	
Dunbar, Marian	PhD	March 1998	Quantitative Inventory of the irrigated cotton soil for sustainable land resource management - Project 1.2.1	USYD	Prof. A McBratney Dr I Odeh	USYD USYD	APA	Due to submit end 2001
Bedrossian, Sevag	PhD	January 2000	Potassium Status and Mineralogy of Soil in relation to premature senescence	USYD	Dr Balwant Singh	USYD	CRDC	Due to complete in 2003
Davies, Andrew	PhD	14 February 2000	Ecology of the Trichogramma egg parasites in the Ord River Irrigation Area and their role in cotton IPM	UQ	Prof Myron Zalucki	UQ	CRDC	
Britton, Dave	PhD	1 August 1999	Studies of slow release formulations for semiochemicals in cotton pest management	UNE	A/Prof Peter Gregg	UNE	CRDC	
Stewart, Craig	PhD	July 1998	Development of 'Nutrilogic' for precision agriculture - a decision support system for agrotechnology transfer in the cotton industry	USYD	Prof Alex McBratney	USYD	CRDC	
Angelucci, Constanza	PhD	February 1998	Binding sites for the Cry1Ac delta-endotoxin of Bacillus thuringiensis in Helicoverpa	ANU	Dr Ray Akhurst	CSIRO Ento	CRDC	Due to submit end 2001
Wade, Mark	PhD	28 February 2000	Biology, ecology and utilisation of the Damsel Bug as a predator in cotton - towards real IPM	UQ	Prof Myron Zalucki	UQ	CRDC	
Lea, David	PhD	1 March 1999	Risk factors for silverleaf whitefly outbreaks in cotton	USQ	Prof Myron Zalucki	UQ	CRDC	
Cottage, Emma Louise	PhD	1 February 1998	Management of resistance in Bemisia tabaci to insect growth regulators and juvenile hormone mimics	UNE	A/Prof Peter Gregg	UNE	CRDC	Due to submit in 2002
Yan, Florian	PhD	1 February 2001	Cotton Soil Health: influence on cotton root diseases	USYD	Dr Les Copland, Dr Tony Vancov, Dr David Nehl, Dr David Backhouse.	USYD NSW AG NSW AG UNE	Cotton CRC	Due to Complete June 2004
Gulino, Lisa	PhD	1 July 2000	Molecular diagnosis of Fusarium wilt of cotton in Australia	CRCTPP	Dr Suzy Bentley	UQ	Cotton CRC	Due to Complete June 2003
Downey, Adam	PhD	1 July 2000	The effects of cotton defoliants on native trees from north western NSW field based experiments.	UNE	Dr John Duggin Mr Guy Roth	UNE	Cotton CRC	Due to complete September 2003

Project Number: 4.1.6 AC(a)

Summer Scholarship: Do *Helicoverpa armigera* Moths Learn to Associate Odours of Plant Volatiles with Food Reward?

AIMS

The aims of this project are to:

- investigate whether *H. armigera* moths learn to associate odours of plant volatiles with a food reward
- determine whether learning is related to the number of exposure of moths to the plant volatiles and the food reward.

STAFF

Richard Tennant, Scholarship recipient, University of New England
Dr Alice Del Socorro, Project Supervisor, University of New England

PROGRESS

Insects learn to associate olfactory cues with environmental factors such as food sources or presence of predators. The project investigated whether *H. armigera* female moths learn to associate the odour of plant volatiles with food reward. Classical conditioning

experiments were conducted in the laboratory using 2-day-old unmated females, where individual moths were harnessed in 1.5 mL eppendorf tubes with the tips cut off, so that only the head and antennae protruded from the cut end. Moth learning was scored by means of the proboscis extension reflex (PER) response to phenylacetaldehyde alone, during two post-conditioning periods, after 15 and 120 minutes.

One experiment determined whether associative learning occurred, and whether such learning was related to the number of conditioning trials the moths had experienced. Six groups of moths were given the following numbers of conditioning trials:

- Group 0 - CS (phenylacetaldehyde) only, no US (sucrose)
- Group 1 - one CS-US
- Group 2 - two CS-US
- Group 4 - four CS-US
- Group 6 - six CS-US
- Group 8 - eight CS-US trials.

The percentages of moths that were given two or more CS-US conditioning trials and exhibited PER after 15 and 120 minutes were significantly higher than those given the CS alone. PER was much higher in moths that had more CS-US conditioning trials at 15 minutes. Results from another experiment have shown that non-associative learning may be unlikely. Five groups of moths were conditioned six times to 5 different types of conditioning trials: CS-US paired, CS or US unpaired, CS alone, US alone and Air alone. Of these groups, only the CS-US group showed significant PER response after 15 or 120 minutes. The CS alone did not induce learning.

The findings from this project have shown that learning can occur in *H. armigera* female moths, and that moths can learn to associate plant volatile odour with food. Associative learning is likely to be influenced by the number of conditioning trials the moths have experienced. In nature, insects might need olfactory cues to locate food sources but gustatory cues are also important to make them stay and use these food sources. Outcomes from this project provided insights into possible constraints when using synthetic plant-derived attractant lures for moths in the field. It is conceivable that moth attractiveness to these lures might be affected by the presence of flowering host plants near where the lures are applied. Thus, it is possible that one type of attractant lure might work in one field situation but not in another depending on the availability of nectar sources in the surrounding vegetation.

Groups (no. of CS-US conditioning trials)	N	% PER at 15 min.	% PER at 120 min.
0	20	0	0
1	14	0	14.3
2	19	31.6	31.6
4	18	72.2	38.9
6	15	66.7	53.3
8	20	60.0	40.0

Table 5. Percentages of moths that exhibited proboscis extension reflex (PER) at different CS-US conditioning trials. CS is the conditioned stimulus (phenylacetaldehyde) and US is the unconditioned stimulus (sucrose).

Type of conditioning trial	N	% PER at 15 min.	% PER at 120 min.
CS-US paired	21	52.4	28.6
CS or US unpaired	23	4.4	0
CS alone	19	0	0
US alone	22	4.5	0
Air alone	17	0	0

Table 6. Percentages of moths that exhibited proboscis extension reflex (PER) when given different types of conditioning trials. CS is the conditioned stimulus (phenylacetaldehyde) and US is the unconditioned stimulus (sucrose).

Project Number: 4.1.6 AC(b)

Summer Scholarship: Quantifying *Helicoverpa armigera* Egg Dispersal

AIMS

The aims of this project are to:

- quantify the mean and variance of the distance between eggs laid by individual female moths
- estimate the two-dimensional spatial dispersion of a female moths egg load
- determine the times during the night at which female *Helicoverpa armigera* lay their eggs.

STAFF

Ms Sabina Kindler, Summer Student, University of Western Sydney, Hawkesbury
Mr Martin Dillon, CSIRO Entomology, Research Projects Officer
Ms Trudy Staines, CSIRO Entomology, Technical Assistant

PROGRESS

Helicoverpa *dispersion*

Nine thousand three hundred and fifty three eggs and larvae were collected from a total of 1174 m of pigeon pea and sorghum. The sampling was undertaken at a range of scales, from 5 x 5 m plots to a 90 x 490 m block. All specimens for each individual metre were kept separate and were stored in alcohol. In the near future they will be analysed by Dr Glenn Graham's lab at the University of Queensland to categorise microsatellite markers that may allow the identification of siblings. Positively identified siblings will then be analysed on a spatial basis by Martin Dillon to quantify how individual female *Helicoverpa* disperse their egg loads.

Timing of egg laying

Two nocturnal field trials were undertaken in which replicates of selected plants were bagged to exclude moths, and subsequently exposed for set periods through the night to allow moths to access them. In both cases low overall egg densities in treatments and controls precluded robust statistical analysis. Three laboratory-based trials in a constant temperature cabinet with adjustable light regimes were undertaken. The results showed that a high proportion of eggs are laid in the first hour after dusk. However, a significant and substantial proportion of a female's egg load was often laid after midnight (contrary to published results). Furthermore a very strong influence of human disturbance (while counting eggs) on oviposition behaviour was recorded (also contrary to the few published papers pertinent to *Helicoverpa*). It is clear that field based exclusion experiments will give the best measures of the timing of egg lays, and so this work will be repeated next season by Martin Dillon.

Sabina Kindler (left) and Trudy Staines during field work

Project Number: 4.1.6 AC(c)

Summer Scholarship: Egg Parasitoids of *Heliothis* in the Byee Cotton Growing District

AIM

The aims of this project are: to evaluate the natural levels of egg parasitism in the Byee growing district and determine if egg parasitoids can be incorporated into existing IPM practices in the district; to introduce *Trichogramma pretiosum* into the Byee district by completing an insoculative release; and to conduct pre-and post-release sampling.

STAFF

Sarah Curry, Summer Student, University of Queensland
Brad Scholz, Department of Primary Industries Queensland, Toowoomba

SUMMARY

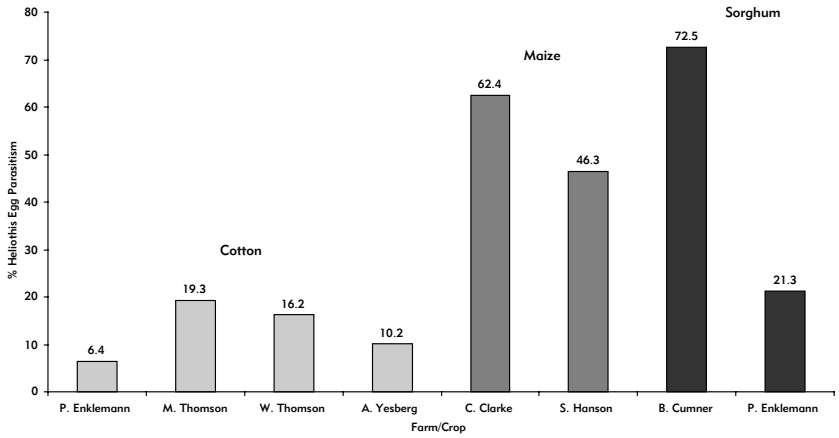
From 8 January to 9 February 2001, heliothis eggs were collected from cotton, maize and sorghum farms in the Byee district, a diverse farming region in southeast Queensland. During this time, overall parasitism of heliothis eggs was 12.9% in cotton, 56.0% in maize and 58.6% in sorghum. Solid plantings of Ingard cotton had higher rates of parasitism than mixed planting of conventional and Ingard cotton. The *Hymentopteran heliothis* egg parasitoids included *Trichogramma*, *Trichogrammatoidea* and *Telenomus*, *Trichogramma* being the most abundant. From the sampling data, four conclusions were obvious, as follows:

- sorghum and maize were better sources of *Trichogramma* than cotton (Figure 9)
- sorghum and maize may be preferred by *Trichogramma* because they are usually sprayed less, leading to increased parasitoid survival or activity or both and consequently higher levels of egg parasitism
- rates of parasitism varied greatly between farms and even between paddocks
- most of the egg parasitoids were species of *Trichogramma*.

On 23 January 2001 about six hundred thousand *Trichogramma pretiosum* were released in an unsprayed sorghum paddock next to a paddock of conventionally sprayed cotton. The parasitism rates increased 45% from non-release to release sorghum. Sixteen days after release, the levels of egg parasitism also rose in the cotton that was next to the field, but were lower in the cotton rows that were furthest away from the sorghum.

In conclusion, the results of this project show that *Trichogramma* are indeed present in the Byee district and are having a varying affect on heliothis in cotton and grain crops. The relatively low rates of parasitism and uncertain farmwide effects of a single, localised *Trichogramma* release suggests that this practice is currently not a viable method for heliothis control in cotton at Byee. As our understanding and attitude towards IPM evolves, future IPM programs may be able to include augmentation of beneficial populations such as *Trichogramma* as a reliable tool to combat heliothis populations and other pests of cotton and grain crops.

Figure 9. Overall percent parasitism in Byee district by farm and crop



Project Number: 4.1.0 AC(SX3)

Scientific Exchange Summary – Martin Dillon Visit to Brazil and USA, 19 August – 6 September 2000

AIMS

Aims of the exchange were:

- To attend and present a paper at the XXI International Congress of Entomology.
- To gain an overview of the state-of-the-art in fields pertinent to our research on *Helicoverpa* and its management within Australian cotton production systems.
- To identify opportunities and new techniques applicable to our research.
- To meet and hold discussions with scientists researching the development and deployment of insect pest management strategies for cotton, in particular area wide management (AWM), and Bt resistance management for *Helicoverpa* and other noctuids. At each laboratory visited I presented a 30-minute seminar entitled "Evaluating trap crops and Bt refuges for a very mobile pest: *Heliothis* in Australia".

ITINERARY

20-27 August 2000:	XXI International Congress of Entomology, Iguassu Falls, Brazil
28-30 August 2000:	North Carolina State University, Raleigh
31 August-1 September 2000:	USDA-ARS Southern Insect Management Research Unit, Stoneville, Mississippi
2 September-5 September 2000:	USDA-ARS Areawide Pest management Research Unit, College Station, Texas

Funding: Australian Cotton CRC $5000, CSIRO Entomology Travel Grant $1000

OUTCOMES

The aims of the scientific exchange were overwhelmingly achieved. Attending the XXI Congress was a terrific experience. It allowed me to meet and listen to leading scientists across the full breadth of entomological research and gain fresh insights and new ideas for techniques, interpretations and management strategies. It also allowed me to establish contacts and to explore potential future collaborations. I was also able to put my own and my colleagues' research at ACRI and more broadly within the Australian cotton industry into a world perspective.

The study tour of the US research labs was equally rewarding and enlightening. It was interesting to see and compare the differences and similarities in cotton insect pest management between the US and Australia. I have returned with new perspectives, new ideas, and valuable contacts. I had valuable discussions with the following key scientists: Professor George Kennedy (NCSU) and Professor Fred Gould (NCSU), Dr Dick Hardee (USDA Stoneville) and Dr John Westbrook (USDA College Station). I was given a comprehensive overview of research projects at each location, spending time with 19 scientists.

Project Code 4.1.0 AC (SX2)

Scientific Exchange: Study Tour of Key Area Wide Pest Management Research Centres Texas and Mississippi, USA, 4 to 17 June 2000 - Dr Melina Miles

AIM

The aim of the exchange was to meet with researchers engaged in the development and application of areawide insect pest management strategies in mixed cotton and grain farming systems in southern USA. The purpose of doing this was, through discussion, to

identify opportunities for applying new techniques or technology or both to Australian AWM strategies, exchange information related to the research and development of AWM programs and to establish a network of contacts in this field of research. Key USDA research facilities were visited, i.e. Stoneville in Mississippi and College Station, Texas.

Discussions and field trips were had with numerous researchers, extension staff, farmers and private consultants during the visit. These idea sharing opportunities were of considerable benefit in terms of developing an understanding of the state of research in the field of area-wide pest management.

Although the implementation of AWM strategies for *Helicoverpa* is not as advanced in the USA as it is in Queensland, there are a number of tactics and tools being developed there that have application to the Australian farming system.

Ultimately, the discussions that took place will be of benefit to the ongoing development of AWM of *Helicoverpa* species in Australian farming systems.

Project Code: 4.1.0 AC (SX4)

Scientific Exchange: Study Tour of Textile Research Facilities and Conference Attendance, USA, September 2000 - Dr Jackie Cai

The activities for this travel included:

- Attending 2000 AATCC (*American Association of Textile Chemists and Colorists*) International Conference & Exhibition at NC, USA.
- Meeting with researchers and managers from Procter & Gamble and Reckitt & Benckiser.
- Visiting Cotton Incorporated, the research and development centre and new world headquarters in Cary, NC, and North Carolina State University.

Dr Cai presented a paper entitled "Bleaching of Cotton and Cotton/Wool Blends with TAED and NOBS Activated Peroxide Systems" at the AATCC conference. The presentation was well received, and the paper was selected for a full peer review for publication. It is now in print. During the conference, Dr Cai met with the researchers and managers from Procter & Gamble and Reckitt & Benckiser. In addition to general discussion on some technical and commercial issues, the potential for collaboration on textile bleaching and bleach activator research was discussed. After the conference, Dr Cai visited Cotton Incorporated at Cary, and North Carolina State University at Raleigh, NC, where she had discussions on research work and technical services carried out there and also toured their research and education facilities. Of particular value to Dr Cai were her discussions on issues of white speck, Barre (Barre is still a problem in US), cationic cotton dyeing with low or no salt and alkali, cotton blends and mercerisation. The scientific exchange program provided Dr Cai with valuable experience and allowed her to update technical information and knowledge, and improve contacts with overseas industry and research organisations.

Project Number: 4.9.1

Scientific Exchange: Responses of Cotton to Transient and Persistent Water Deficits

AIM

This project was initiated in response to the recent impetus to increase water use efficiency in Australian cotton cropping systems and its aim was to improve understanding of the physiological responses of cotton cultivars to water limited conditions. This improved understanding may contribute to improved water management of irrigated and rain-fed cotton.

STAFF

Dr Tom T. Lei, CSIRO Plant Industry, Narrabri
Professor Mitsutoshi Kitao, Hokkaido Research Centre, Forestry and Forest Products Research Institute, Sapporo, Japan

PROGRESS

We conducted two experiments, one in the glasshouse where we controlled and monitored the rapid drying of individual plants, and one in the field where the gradual water depletion under natural conditions was recreated. Eight cotton cultivars of various leaf types, statures and heat tolerances were used to examine their differences in drought response. In the glasshouse, physiological responses of cotton during a 5-day period (to leaf wilting) when water was withheld were compared to fully watered plants. In the field, similar measurements were taken on regularly irrigated plants and those without water input (i.e. irrigation and rain excluded by plastic ground sheet) for 8 weeks. Physiological properties measured included maximum photosynthesis, transpiration, leaf internal CO_2, CO_2 response curves and leaf temperature. We also took chlorophyll fluorescence measurements to reveal the detailed photosystem functions (i.e. electron transport rate and degree of photoinhibition) of drought stressed plants.

Our results showed that, under short-term water deficit in the glasshouse, cotton plants were able to maintain normal transpiration and photosynthesis until just before the permanent wilting point in 4 to 5 days. The relationship between leaf internal CO_2 and transpiration indicates that physiological water use efficiency is not maximised by current cultivars with possible room for improvement through breeding. Under persistent water stress created in a field experiment, we found leaf acclimation by stressed plants in lower specific leaf area and higher chlorophyll concentrations than irrigated plants. These adaptations allow stressed plants higher light energy capture but also represent higher risks to photoinhibition (particularly in combination with low leaf water potential). However, chlorophyll fluorescence measurements indicate that stressed plants were less vulnerable to photoinhibition because they can maintain high electron transport rate through the photosynthetic systems despite the stress. This is a key finding implying that cotton under water stress is capable of high energy dissipation through alternative electron pathways involved in photorespiration and perhaps the Mehler reaction. Higher Rubisco (the major photosynthetic enzyme) activities and higher rates of RuBP (Calvin Cycle substrate) regeneration in stressed leaves are consistent with a higher capacity for alternate energy consumption. Modern cotton genotypes, we conclude, have inherently desensitised stomatal response to declining available water, but are capable of maintaining high energy flow through effective dissipation mechanisms under moderate water stress.

Technical Officer Andres Spragge addressing growers at his Dalby trial site.

Program Four Extension Activities

Utilisation and Application of Research and Links with Users

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

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 has established on-farm demonstrations and field trials with grower and consultant participation. This is enhanced by the continued operation of grower groups and support networks to discuss and disseminate these findings.

AIMS

The aim of this project is to provide 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 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 IPM and AWM support groups
- examining social barriers to technology adoption.

PROGRESS

The extension and adoption process established by the CRC for Sustainable Cotton Production continues to provide an excellent foundation for the development of a cohesive, well focused and coordinated extension team. The cotton extension team, which includes extension officers in NSW Agriculture, Department of Primary Industries Queensland and CRDC, has a national focus on major industry issues and a prioritised list of regional problems. The Australian Cotton CRC has funded two officers in the extension team and provides the leadership and coordination of a team.

The CRC Cotton Extension Committee, which comprises Dallas Gibb and Gus Shaw, NSW Agriculture; Geoff McIntyre, Department of Primary Industries Queensland; Bruce

Pyke and Adam Kay, Cotton Research and Development Corporation; and Bruce Finney, Australian Cotton Growers Research Association, who leads the extension team.

The National Cotton Extension Coordinator, Ingrid Christiansen, who commenced duties in February 2001, coordinates the extension team ensuring a 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.

During 2000-2001 the extension team has included:

- eight industry development extension officers and six water use efficiency extension officers located strategically throughout the industry
- five farming systems extension officers in NSW Agriculture and Department of Primary Industries Queensland who contribute part of their time to cotton industry extension activities
- two spray application development extension officers
- the IPM Training Coordinator in Department of Primary Industries Queensland
- the trainee Industry Development Officer in a position established, and with an officer appointed, at ACRI during the year thus ensuring a trained extension officer is available to fill vacancies as they occur.

The extension team has cooperated with extension staff in the new production areas around Hillston in southern NSW and the Area-Wide Management Development Extension Officer with the Department of Primary Industries Queensland.

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

- farming systems
- disease management
- weed management
- environment
- insect management
- water use efficiency.

The extension officers work closely with regional grower associations and maintain strong links with all research programs. The core activity of the program has been centred on regional field trials and demonstrations in collaboration with researchers, consultants and growers to field test, evaluate and adapt the findings of research.

An annual cotton extension planning workshop provides the opportunity for the extension team, researchers and consultants to identify and prioritise national issues. Some training has been included in the workshop but technical updates will now be provided in other workshops during the season.

Major activities of the program have included:

- the establishment of IPM and AWM grower groups
- a series of insect management, agronomy and farming systems trials in collaboration with research officers and growers
- detailed development and implementation of disease management extension by the CRC Fuscom group
- a large number of pesticide application workshops for growers
- the establishment of regional grower groups and demonstration trials in the Rural Water Use Efficiency Project
- *Cotton Tales* newsletters published at various intervals in all major cotton growing valleys
- publication of regional trial books
- another industry benchmarking study following the first three years ago.

Figure 10. Relative importance of extension activities for national extension issues.

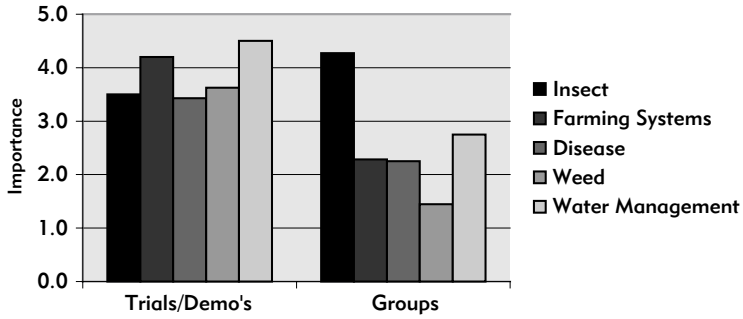
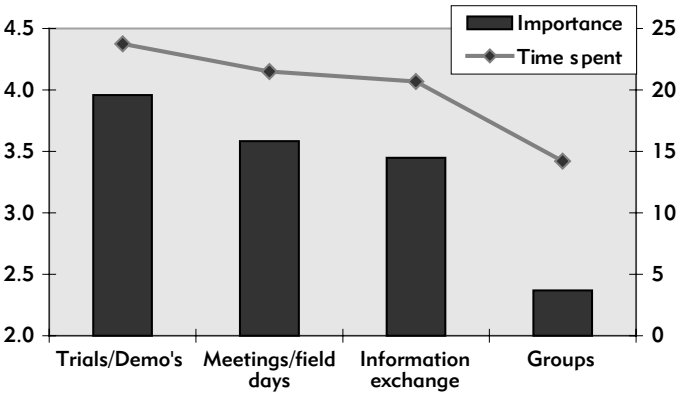


Figure 11. Relative importance and time spent on extension activities.



Extension officers have completed an assessment of importance, time spent and extension methods and activities used on the national industry issues. The results are presented in Figures 10 and 11

Field trials and demonstrations are the main extension methodology being used by the officers. Group processes are most important for insect and water management in accordance with project plans.

Implementation of strategies for IPM and AWM of insects is 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 with the development of a grower focussed training program and by the project undertaking the economic assessment of IPM and insecticide resistance management (IRM) strategies. The assessment is based on data sets from IPM grower groups during the last two seasons and has demonstrated conclusively that fewer insect sprays can be associated with higher profit margins as well as deriving significant environmental benefits.

The Australian 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 the Department of Primary Industries Queensland. The CRC has ensured the development of effective linkages with a similar NSW Agriculture initiative, which is also associated with the CRC.

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 is an effective vehicle for the delivery of new and advanced technical information and management strategies.

Extension officers 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, extension officers also contribute significant support to community and environmental groups in the course of their normal activities and as members of their regional communities. They provide information through regional publications and media outlets, through their membership 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 Australian Cotton CRC.

LINKAGES

The wider extension team includes staff in the Technology Resource Centre, CRDC, Cotton Australia (CA), Cotton Consultants Association, Cotton Seed Distributors and Deltapine Australia.

The extension team has direct linkages with ACGRA nationally through its 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 Research Development and Extension subcommittees.

The extension officers 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.

Project Number: 4.1.2 AC

Postgraduate Certificate and Certificate in Rural Science (Cotton Production)

AIM

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.

STAFF

Mr Guy Roth, Australian Cotton CRC, University of New England, Armidale
Associate Professor Robin Jessop, Agronomy and Soil Science, University of New England

PROGRESS

Milestone 1

To run the four cotton units for Certificate and Post Graduate Certificate students. From 20 to 30 students will graduate from the course each year.

- The cotton course was overbooked for the 2001 intake. This reflects strong demand and support by industry. A very large intake of forty five people was admitted in 2001 to cater for this strong demand and to reduce the waiting list (Table 12). These large intakes are a trade off between class size and course quality. Table 12 shows there is a steady increase in the proportion of people enrolling at the Certificate level.
- Twenty people graduated from the course in April 2001 at The University of New England (Table 13). A total of a hundred and twelve people have now graduated with 46% of this total having completed the course in the last two years.
- About 30 Cotton CRC staff and other industry personnel deliver specialised lectures during the course residentials.
- Figure 14 shows the occupations and locations of course graduates. Participants come from all cotton growing areas in Australia and are mostly agronomists, farmers and consultants.

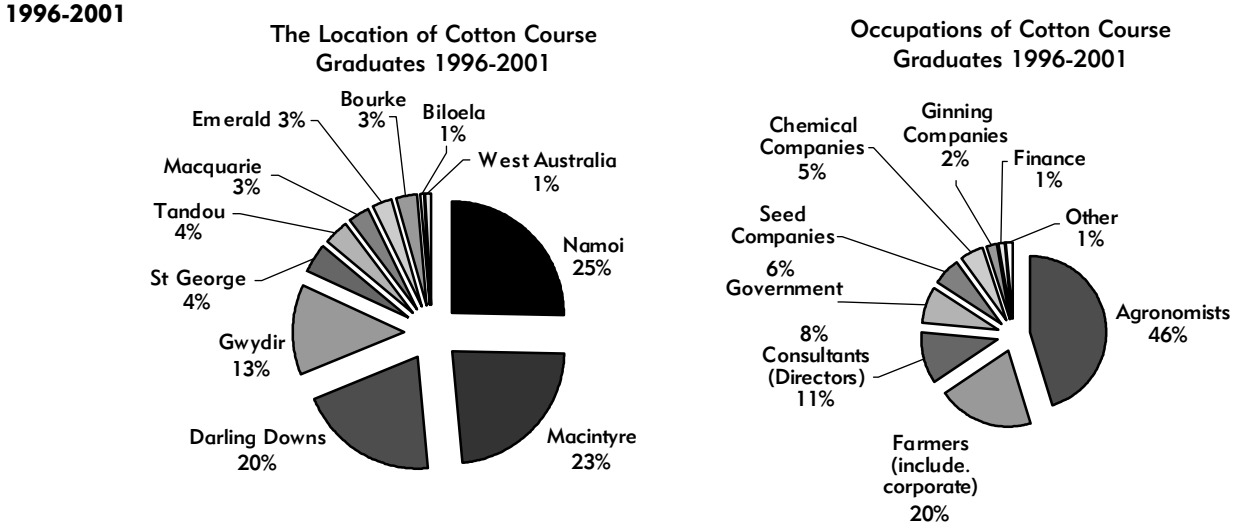
Table 12. Cotton course student applications.

Year	1994	1995	1996	1997	1998	1999	2000	2001
Postgraduate	19	13	14	16	24	17	17	19
Certificate	8	4	6	12	8	17	18	26
Total	**27**	**17**	**20**	**28**	**32**	**34**	**35**	**45**

Table 13. Cotton course graduates.

Year	1996	1997	1998	1999	2000	2001	Total
Postgraduate	12	10	11	14	18	11	76
Certificate	1	4	3	6	13	9	36
Total	**13**	**14**	**14**	**20**	**31**	**20**	**112**

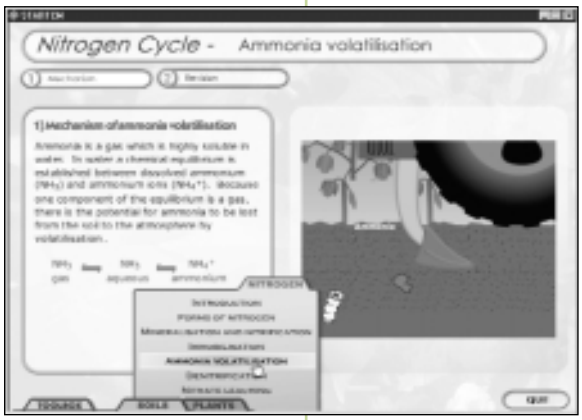
Figure 14: Internal undergraduate students and their educational institutes who undertook a cotton unit 1996-2001



Milestone 2

Update and review course content and materials to meet industry needs as required. Initiate plans to provide a refresher course for graduates.

- The course restructure from three to four units is now complete. All unit note materials have been updated in the last 12 months.
- No plans have been made for a refresher course and this will be evaluated as part of a future business plan for the course in 2002.
- The *Cotton Modules* CD ROM is now available to students. This CD contains multimedia (video and graphics) teaching activities for students. All the unit notes have been converted to PDF format and are also on the CD. The CD ROMs have a security system so that they cannot be installed on unauthorised computers. This protects the intellectual property of the course materials.
- Each unit now has a password protected website where students log on and interact with each other from their homes. It includes a bulletin board, quiz assessment tools, internet links and references. This allows students to interact with each other more often outside the residential period.



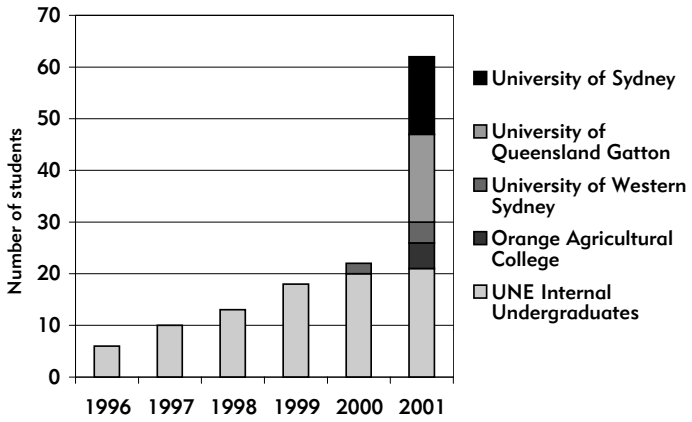
An example of the multimedia graphics on the Cotton Modules *CD ROM.*

Milestone 3

Train undergraduate students as part of their undergraduate degrees by offering the Applied Production Unit and supervising honours projects at UNE and other institutions.

- Twenty-one students at UNE completed the Applied Cotton Production Unit as part of their undergraduate studies in Rural Science, Agricultural Economics and Agribusiness. The unit continues to have one of the highest enrolments of all Rural Science electives at UNE.
- Mr Scott Wallace is undertaking his honours project on responses to herbicides of biotypes of the bladder ketmia weed.

Figure 15. Number of undergraduate students doing the Applied Cotton Production Unit as part of their Agricultural Science degree (1996-2001).



Milestone 4

To develop a plan to deliver the Cotton Course and an undergraduate program at other Australian universities and for international students.

- There has been a significant increase in the number of undergraduate students undertaking the Applied Cotton Production Unit as part of their Agricultural Science degrees at their respective university. Figure 15 shows that sixty-one students undertook the unit at five universities in First Semester 2001.
- At the University of Queensland (Gatton) 21 students undertook the unit. An agreed fee was negotiated and a 2-day residential was run at Gatton. At The University of Sydney fifteen students were given a 3-day residential in Sydney. The cost of this was met by the project. They were joined by three students from The University of Western Sydney (Hawkesbury) who paid the normal HECS fees. There are also five students at Orange Agriculture College undertaking the unit. A short residential was held for them in Orange and they are paying the normal HECS fees.
- International Market. Planning meetings have been held and funds committed but not spent to develop a market research and business plan using proceeds from the course income.
- A draft business plan has been prepared on the current course. This will be further developed in preparation for the ramp down of Cotton CRC funds from 2003.

Australian Cotton CRC Course Coordinator, Guy Roth (left), Federal Treasurer, Hon. Peter Costello MP (centre), and Australian Cotton CRC Chief Executive Officer, Dr Gary Fitt, receiving the Business and Higher Education Round Table national collaborative training award in December 2000.

Graduation 2001. (l to r) Chris Grant (Toowoomba), Alison Young (Walgett), Guy Roth (Course Lecturer), Kirrily Quade (Bourke), Graham Boulton (Toowoomba), Amelia Reddall (Narrabri), David Schulze (Dalby), Dr Gary Fitt (Cotton CRC, CEO), Associate Prof. Peter Gregg (Armidale)

Project Number: 4.2.2AC

Improving On Farm Water Use Efficiency in the Queensland Cotton and Grain Industries

AIMS AND MILESTONES

This project is being conducted within Queensland Government's Rural Water Use Efficiency Initiative as the Cotton and Grains Adoption Program. The aim is to increase irrigation efficiency in the cotton and grain industries by at least 10% and have 70% of growers adopting best management practice guidelines, which will be developed for general application for the irrigation of all crops.

The milestones are listed (1 to 10) in the progress section below.

STAFF

Mr Geoff McIntyre, Department of Primary Industries Queensland, Dalby
Dr Phil Goyne, Department of Primary Industries Queensland, Warwick
Mr John Okello-Okanya, Department of Primary Industries Queensland, Emerald
Mr Andres Spragge, Department of Primary Industries Queensland, Dalby
Ms Sarah Hood, Department of Primary Industries Queensland, St George
Mr Darren Springer, Department of Primary Industries Queensland, Biloela
Ms Sandy Cameron, Department of Primary Industries Queensland, Goondiwindi

The Rural Water Use Efficiency Project Team.

PROGRESS

During the past year the project has made considerable progress in the following areas:

- it has been 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
- irrigation benchmark data have been collected from the demonstration sites in both cotton and grain crops.

It has been the task of the Cotton and 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.

EM34 used for reconnaissance surveys.

1. Benchmarking and demonstration winter trials 2000

Preparations for the establishment of the program in the five regions and lack of water in some led to limited opportunities to initiate demonstration sites in winter crops in 2000, although two sites were established with wheat and faba beans.

2. Benchmarking and demonstration summer trials 2000-2001

The objective in each region was to have four demonstration/trial sites each year at which various technologies could be demonstrated and existing practices benchmarked. Grower interest and their need for answers to problems resulted in more than four sites being established in some regions.

Demonstrations have been successfully established in the Emerald, Callide/Dawson, Darling Downs, Goondiwindi and St. George regions. Crops have included cotton, sorghum, peanuts, maize and navy beans. Irrigation systems have involved furrow, subsurface drip, centre pivot and side roll sprinkler. In some cases opportunities have been available to compare the efficiencies of two systems on the same soil type. In two regions, polyacrylamides (PAM) have been used to evaluate their impact on irrigation efficiency. In each region soil types on which the trials have been established have been varied. Irrigation scheduling systems and a range of scheduling tools have also been evaluated.

3. BMP for Irrigation- preliminary module drafted

The irrigation management module for BMP is being developed by the Australian Cotton Growers Research Association under a Cotton Research and Development Corporation funded project and will satisfy the BMP requirement of the Cotton and Grains Adoption Program. The Cotton and Grains Adoption Team is providing information towards the development of this module. The cotton BMP manual will be (with some modification) suitable for the irrigated grains industry.

4. Awards program developed

The objectives of the irrigator awards program are to promote the Rural Water Use Efficiency Initiative, reward achievements and cooperation, and encourage better water management and innovation. It was considered that, as the Adoption Program was in its initial stages, it was premature to try to single out superior irrigators. Consequently, staff in each region are planning awards functions where cooperators and those who have been active in the program over the last year will be recognised.

Furrow irrigated cotton.

5. Consultative Committee Meetings

The fourth Cotton and Grains Adoption Program Consultative Committee meeting was held in Dalby 13 June 2001. This committee, which meets twice per year, includes representatives of stakeholders in the program: Queensland Department of Primary Industries, AFFS, FSI, Department of Natural Resources and Mines, Australian Cotton CRC, Cotton Australia, Agforce, Cotton Research and Development Corporation, Australian Cotton Research Institute, cotton grower organisations, crop consultants and irrigated cotton and grain grower representatives from the regions.

6. Liaison with other industries involved with RWUEI

There has been considerable interaction with the sugar, fruit and vegetable and dairy industries in the regions. Joint field days and workshops have been held and in some cases trial sites shared. The Cotton and Grains Team visited the sugar adoption staff in Bundaberg during April.

7. Liaison with Department of Natural Resources and Mines, University of Southern Queensland National Centre for Engineering in Agriculture

Liaison with the Department of Natural Resources and Mines is ongoing and their representatives are members of the regional management committees. Department staff participate in numerous meetings and field days. From its commencement, the University of Southern Queensland (USQ) National Centre for Engineering in Agriculture has been involved in the Cotton and Grains Program.

8. Benchmarking trials and demonstrations completed

All the 2000-2001 field trials are almost completed with some yield figures still to come. Initial data analysis indicates a number of areas where management changes can be made to improve water use efficiencies.

9. Year 2 Evaluation of awareness and adoption completed

Cotton and Grains Program staff have surveyed many of the irrigators in their region to evaluate awareness of the project and implementation of BMP. The St George/Dirranbandi survey indicated that:

- 89% of growers were aware of the program
- 78% had read the project's newsletter
- 56% had attended meetings
- 100% had attended a BMP workshop.

In the Goondiwindi- Macintyre region, at least 50% of growers had attended meetings. In the Callide/Dawson region, awareness of the RWUEI and the project was as high as 100%. In the Emerald region, awareness was a little over 40% and BMP involvement and participation was 15 to 20%. On the Darling Downs, awareness of the project is about 75%.

10. Year 2 Review and reports completed and future plans developed

Regional cotton and grains officers are planning their 2001-2002 summer activities following an evaluation of the results that will be to be presented to regional groups in June. Winter 2001 trials are being established in some regions.

ADDITIONAL ACTIVITIES

Communications

Project officers have been very active in promoting the project via fax, email and telephone. All have contributed to the three editions of the project's newsletter, *Water Works*. In addition, the program has been promoted through the following channels:

- St George/Dirranbandi - *Cotton Tales*, *Balonne Broadcaster*, *Balonne Beacon*
- Goondiwindi-Macintyre Valley - *Country Courier* and *Cotton Tales*
- Darling Downs - local and regional newspapers, *Cotton Outlook*, *Cotton Insight*, *Queensland Country Life*, ABC Radio
- Callide/Dawson - *Cotton Tales*, *Dawson Callide Gazette*, ABC Radio, WIN TV
- Nogoa/Emerald and Mackenzie/Fitzroy - *Cotton Tales*, local papers, local radio, *Queensland Country life*, *Central Highland News*.

Financial Incentives Scheme

The Financial Incentives Scheme is being delivered by Cotton Australia in collaboration with Agforce on behalf of the cotton and grains industries. Irrigated cotton and grain growers have been informed of the scheme via regional grower group meetings, field days, fax, newspaper articles and radio interviews.

Under the scheme irrigators can be granted a subsidy of up to $1500 towards the purchase of equipment or training to enhance water use efficiency.

To date, the cotton and grain industries have been slow to become involved in the scheme due mainly to the lateness of the summer irrigation season when it was introduced. In some cases growers are waiting for further progress in the project before deciding on their choice of equipment.

CONCLUSIONS

The Rural Water Use Efficiency Initiative Cotton and Grains Adoption Program extension officers and technical officer (Sarah Hood, Sandy Cameron, John Okello-Okanya, Darren Springer and Andres Spragge) were responsible for much of the information and data reported here. These officers have done a magnificent job (in some cases under difficult circumstances) in the first full season of the project and are making a major impact on the cotton and grains irrigation industries in their regions.

Project Number: 4.2.3 AC

Cotton Industry Development Officer - Gwydir

AIM

The aim of this project is to develop and promote the adoption of improved technologies and practices to ensure that the cotton industry is economically and environmentally sustainable.

STAFF

James Quinn, Australian Cotton CRC and NSW Agriculture

PROGRESS

Cotton IPM and AWM Grower groups

Three additional groups were formed adding to the four already existing, including most of the cotton growers in the Gwydir Valley. Groups mostly met monthly. Attendance was as high as 82.5% at some meetings (Bullarah).

Group members planted chickpea trap crops to catch the first generation of *Heliothis* moths emerging from diapause. Some also used early sorghum plantings and Gemstar® to trap second generation *H. armigera*. Many groups conduct comparative analysis and benchmarking to examine their crop and insecticide use, subsequently challenging their seasonal insecticide use. The Gwydir Valley Extension Committee (leading cotton growers and consultants) remained active, prioritising extension activities within the valley and producing a year and trial booklet.

Insect management

A series of four trials were conducted to examine different aspects of insect management during the 2000-2001cotton season. Three of these trials examined crop response from early season damage. Better understanding of this characteristic will help reduce the use of early season insecticide, promoting beneficial insects.

A trial examining the effects of early tipping of the plant terminal, showed that high amounts of terminal damage can be tolerated without affecting yield or maturity. Two trials examined the effects of first flower fruit retention of first and second position fruit. Another trial looked at fruit removal through the flowering period and its effect on crop growth, development and yield.

Other trials involved the use of the NPV and dealt with issues relevant to area-wide management of *Heliothis*. A trial was established, firstly, to assess the robustness of these products against *Heliothis* and, secondly, to reduce the number of pupae emerging from under crop.

Disease awareness

Fusarium wilt was identified on two new properties in the Gwydir Valley during the season, prompting increased liaison and meetings between cotton growers, consultants and plant pathologists.

Farming systems

Ultra narrow row plantings were trialled. Two rows per metre were planted 0.2 m apart on top of the bed. Similar yields were obtained. A major benefit was six days of earliness, with further earliness potential possible with better management.

A case study was conducted comprising a combination of management and agronomic techniques known to assist in IPM-friendly cotton production. It included chickpea trap crops, conventional cotton planted into wheat stubble, INGARD cotton used as an early season trap crop, and strategic plantings of sorghum and lucerne to provide additional trap crops, as well as refuges for beneficial insects and selective chemistry.

OTHER ACTIVITIES

Other activities included:

- Thirty two *Cotton Tales* bi-weekly one-page newsletters were sent during the season to growers and consultants in the Gwydir Valley.
- The Gwydir Valley Cotton Field Day Committee (chaired by James Quinn) held a major field day, which attracted 80 people and included visits to several farms. Associated programs included local irrigated and dryland cotton crop competitions, and installation of regional weather stations.
- A weekly association with radio 2VM Moree assisted with the extension of trial work and notification of district field days, being beneficial in boosting the public profile of the Australian Cotton CRC.
- The CRC Extension Team occupied the Research Pavilion at the Moree Cotton Trade Show, providing an opportunity for each of the focus teams to display posters and material.

Project Number: 4.2.4 AC

Integrated Pest Management (IPM) Training Coordinator

AIMS AND MILESTONES

Aims for the project are to:

- develop a nationally accredited (National Competency Standards - Rural Training Council of Australia and Vocational Education and Training Advisory Board approved) grower short course in IPM for the Australian cotton industry
- develop a comprehensive grower focused IPM manual for the Australian cotton industry
- coordinate the implementation and ongoing development of an IPM short course
- have 20% of growers attend the course by June 2001
- work with industry researchers and extension staff to improve the transfer of information to growers and consultants who aim to increase the level of adoption of IPM strategies within the Australian cotton industry
- assist in training district industry development officers (IDOs) in IPM strategies.

The milestones for 2000-2001 were as follows:

1. Develop, in consultation with industry and researchers, a grower focused short course (plus manual) in IPM.
2. Ensure coordination and linkage between existing training courses and extension programs.
3. Collate several case studies of grower and consultant experiences with IPM and use within the course program.
4. Evaluate the use of experienced consultants and growers to assist in the implementation of the program.
5. Ensure participation of research scientists in the program
6. Complete several pilot courses amongst growers and consultants
7. Finalise short course structure and manual
8. Ensure that the course meets the criteria to receive accreditation under a National Training Program
9. Provide training for district IDOs and other staff under guidelines of the National Training Program so they can help deliver the course.

STAFF

Mr Greg Kauter, Department of Primary Industries Queensland, Goondiwindi (until August 2000)
Cotton Seed Distributors, Goondiwindi
Mr Bill Dalton, Department of Primary Industries Queensland, Goondiwindi (from January 2001)
Mr Geoff McIntyre, Department of Primary Industries Queensland, Dalby
Mr Dallas Gibb, NSW Agriculture, Narrabri
Mr Bruce Pyke, Cotton Research and Development Corporation

PROGRESS

Insecticide resistance and its management remains the biggest challenge for cotton growers. The introduction of transgenic technology (INGARD) has provided an opportunity for the industry to refocus on implementing an IPM approach to this ongoing problem.

The CRDC/CRC evaluation of the adoption of IPM within the Australian cotton industry resulted in recommendations which included the need to develop an easily identified package on IPM and to implement strategies which best delivered such a package to growers and consultants. Particular emphasis should be placed on increasing grower involvement in pest management decisions.

The main aim of this project is to help improve the level of adoption of IPM strategies in the Australian cotton industry. To achieve this an IPM training coordinator has been employed to develop a comprehensive grower focussed IPM short course together with an IPM manual. The course has been designed to be incorporated into the Cotton Industry Traineeship and accredited under the National Training Reform Agenda.

The IPM Training Coordinator will complete the development of and implement the grower focused IPM short course. This course has special emphasis on insecticide resistance management; management of transgenic cotton and promotion of whole farm IPM strategies. It aims to increase growers understanding of IPM strategies and to give them confidence in implementing change on their own farms. While it is intended that participants be charged to attend the course, it will not be self-funded, although the revenue generated may provide up to 50% of the project cost. The coordinator will help train district IDOs, as well as help develop national extension programs in IPM.

Despite the unavoidable delays brought about by staff movements and changes, the development process for IPM training workshops is well on the way to completion. The workshop will be presented to the Cotton Industry IPM Reference Group in July-August 2001 for review and approval. It is also expected that by the end of 2001 at least three pilot workshops will be conducted, evaluated and modified where required. It is planned that the IPM training workshops will start immediately after harvest next year with from twelve to fifteen workshops scheduled for 2002.

Project Number: 4.2.5 AC

National Cotton Extension Coordinator

AIMS AND MILESTONES

Aims of the project are to:

- coordinate extension programs directed at regional areawide management IPM groups
- develop a coordinated focus on national extension programs
- develop and facilitate best delivery methods
- facilitate extension training activities
- ensure participation of research scientists in these programs.

Milestones for this year were as follows:

1. Identify national extension priorities for the industry.
2. Develop and implement IPM extension programs focusing on both conventional and transgenic cotton.
3. Establish and monitor links between the extension team, cotton consultants, regional growers associations, research and other industry bodies.
4. Establish links with regional areawide management IPM groups.
5. Coordinate the activities of extension focus teams.

STAFF

Ms Ingrid Christiansen, Department of Primary Industries Queensland, ACRI, Narrabri
Mr Geoff McIntyre, Department of Primary Industries Queensland, Dalby
Mr Dallas Gibb, NSW Agriculture, Narrabri
Mr Bruce Pyke, Cotton Research and Development Corporation

Some of the members of the Cotton CRC Education and Extension Team

PROGRESS

The position of National Cotton Extension Coordinator (NCEC) was first established in 1997 and had been vacant for some 18 months until Ms Ingrid Christiansen was appointed in December 2000 and commenced 19 February 2001. She will be located for the first 15 months of the project at ACRI Narrabri, before relocating to Department of Primary Industries Queensland offices in Toowoomba. The promotion of research outcomes needs to be consistent and well planned to ensure that adoption of new technology occurs throughout the industry. The coordinator will ensure that national extension programs are developed and implemented.

The first priority in this role has been to work closely with the extension team to gain an understanding of each of their activities, identify training needs and enhance linkages and sharing of ideas and practices between regions.

In addition, Ingrid acts as a contact point for researchers in relation to extension possibilities and as a sounding board for extension and communication ideas and to aid in developing communication plans and editing extension materials.

The NCEC works with the CRC Extension Management Committee to develop and act on national priorities in extension. This committee consists of Dallas Gibb, NSW Agriculture; Gus Shaw, NSW Agriculture; Bruce Pyke, CRDC; Geoff McIntyre, Queensland Department of Primary Industries; Adam Kay, CRDC; and Bruce Finney, Australian Cotton Growers Research Association.

The Cotton CRC Extension Team includes 14 extension staff located across the cotton growing regions of Queensland and NSW. They work closely with local growers and consultants to develop their extension activities. It is critical that their work plans are coordinated and meet the national issues facing the industry. This team has been divided into six focus teams, which develop specific extension activities and material for use nationally. Members of the CRC Extension Management Committee have been allocated to specific teams, each with a designated leader.

National Focus	Team Supervisor	Team Leader
Insect Management	Dallas Gibb	James Quinn
Environment/BMP	Bruce Pyke	Peter Hughes
Farming Systems	Gus Shaw	Mark Hickman
Weed Management	Gus Shaw	David Kelly
Disease Management	Geoff McIntyre	Greg Salmond
Water Management	Geoff McIntyre	Phil Goyne

To complement these teams we have also established an Evaluation and Benchmarking Team to examine the rate of technology adoption and changing attitudes towards the adoption of IPM, resistance management and overall changes to the farming system. This team will also coordinate national benchmark surveys that are conducted every 3 to 4 years. The extension team, through the NCEC, has helped gain greater grower involvement in the CRDC sponsored Australian Cotton Comparative Analysis.

All extension team members have conducted an evaluation of at least one of their extension activities. Sharing of results at the annual extension workshop will build on these skills and provide a platform for review and development of specific extension techniques. The development of extension material will be coordinated through the CRC Technology Resource Centre (TRC).

Areawide management is seen as a high priority and tools are being developed to help the extension team support these groups. Sharing of ideas between regions and the use of economic benchmarking of IPM are valuable in enhancing the interest in area wide management.

With a particular focus on insect management and the adoption of IPM, Ingrid is working closely with extension staff in the delivery of information and establishment of field demonstrations which promote IPM. She is establishing links with areawide management groups in each region to ensure that there is a broad level of consistency in the approach these groups take to IPM. This involves coordinating extension material in area such as refuge and host crops management, insect thresholds and the promotion of IPM guidelines.

In collaboration with the Integrated Pest Management Training Coordinator, Bill Dalton, and with Greg Kauter, Ingrid will help develop and deliver an IPM short course for cotton growers.

OUTCOMES

Projected outcomes for this project are as follows:

- coordinated national extension programs
- improved adoption of IPM strategies across the industry
- research and development links with areawide management IPM groups
- development and facilitation of best delivery methods for extension
- development and facilitation of extension training activities
- participation of research scientists in these programs.

Project Number: 4.1.6

An Economic Assessment of Insecticide Resistance Management Strategies in the Australian Cotton Industry

AIMS AND MILESTONES

The aims of this project are to evaluate different IPM and IRM strategies within the industry, particularly with respect to insecticide resistance management, and to develop an economic value for resistance.

As a milestone for the project, by the end of the current funding period an initial analysis of alternative management strategies for insecticide resistance will be completed. This will be based on the Boggabilla data set and analysis of some HEAPS results. There may be some results from the fruit predation model and *OZCOT* incorporated into the analysis.

STAFF

Ziaul Hoque, NSW Agriculture, Narrabri
Bob Farquharson, NSW Agriculture, Tamworth
Martin Dillon, CSIRO Entomology, Narrabri
Greg Kauter, Department of Primary Industries Queensland, Goondiwindi

Ziaul Hoque, Cotton CRC economist, examines the endpoint of the production phase.

PROGRESS

A budgetary analysis has been conducted with the data set, which came from an areawide management group in Boggabilla, northwest NSW, for two seasons (1998-1999 and 1999-2000). Fields were allocated into soft or hard groups based on the types and quantities of insecticide sprays applied. Insecticides were ranked on a scale of 1 to 7 according to their impact on beneficial insects as documented in the *Australian Cotton CRC IPM Guidelines*. Chemicals with a very low impact on beneficial insects (e.g. Gemstar, Bt) were allocated a score of 1, while insecticides that had a high impact on beneficials (e.g. Pyrethroids) were given a score of 7 per application. Each field's overall spray rank was calculated by summing the number of sprays multiplied by their respective scores. The fields with the lowest score tallies (lower 50%) were then categorised as "soft" while those with the highest scores (upper 50%) were classed as "hard".

While yield results were higher in INGARD crops for the soft than hard fields, in conventional crops yields were on average 2 per cent lower than for the hard option in the both years. There were no significant yield differences in the second year in either INGARD or conventional crops. The results showed that average spray costs per hectare were lower (from 17 to 44%) for the soft option

strategy than for the hard option in both INGARD and conventional crops in both years. Average gross margins were higher using the soft option strategy in both years for both INGARD and conventional varieties, averaging 5 per cent more for conventional crops in both years, and 5 per cent more for INGARD crops in the second year, but 25 per cent more in the first year when pest pressure was higher. Average GM and yield was higher in INGARD fields than conventional fields in both seasons. The main message from the study was that substantial financial, management, yield and environmental gains can potentially be made by spraying only when necessary and by using selective, softer chemistry.

The outcomes of this work have been widely publicised with a paper presented in January 2001 at the 45th annual conference of the Australian Agricultural and Resource Economics Society, Adelaide. There were also two papers in the proceedings of the 10th Australian Cotton Conference (August 2000), a poster at the Australian Cotton Grower Trade Show 2001, publications in the *Australian Cottongrower* Magazine, the *Australian Cotton Outlook*, the *Cotton Magazine*, and media coverage.

Detailed planning has been conducted for an analysis of alternative IRM strategies for the IRM component of the project. This has involved discussions with experts at ACRI and drafting of notes for discussion about the issue to be analysed and proposed methodology. A literature review has been completed.

Project Number: 4.3.0 AC

The Australian Cotton CRC Technology Resource Centre

MILESTONES

Milestones for the year were as follows:

1. Continue operation of centre, including responding to individual growers and consultant queries and maintain responsibility for distribution of material including *CottonLOGIC*.
2. Visit all growing regions to promote the Technology Resource Centre and its products.
3. Maintain industry database/mailing/fax list as an integral part of information distribution to industry.
4. Maintain computers and specialised software.
5. Employ temporary assistance to enhance the development of the Cotton CRC internet site.
6. *ENTOpak* inclusions - bunchy top update, vacuum sampling.
7. Produce material in response to special industry needs.

STAFF

David Larsen, Professional Officer, NSW Agriculture

PROGRESS

The Australian Cotton CRC Technology Resource Centre (TRC) has maintained its role as a hub for distribution of research based information to industry and has significantly reduced the load from researchers for day-to-day enquiries, while at the same time providing an excellent portal for enquiries from the public.

The TRC presents information to industry and the community in a number of forms including:

- paper based information sheets and manuals, updates, and scientific publications
- an upgraded website (http://www.cotton.crc.org.au) with electronic versions of many publications plus unique information such as pheromone trap catches on the Cotton CRC website
- CD distribution of the website via the *CottonLOGIC* CD, now distributed to over 1100 users in the cotton industry.

Figure 16. Visits to the Australian Cotton CRC website May 2000 to May 2001

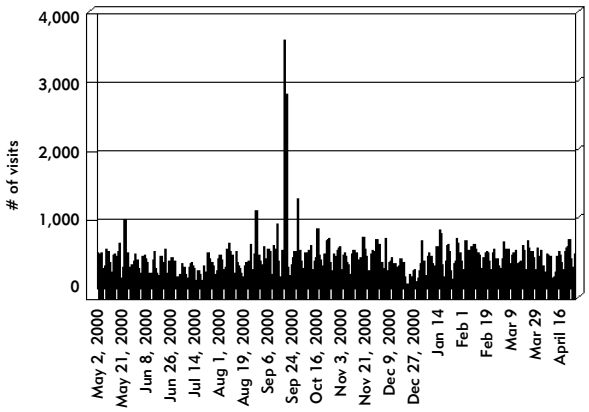
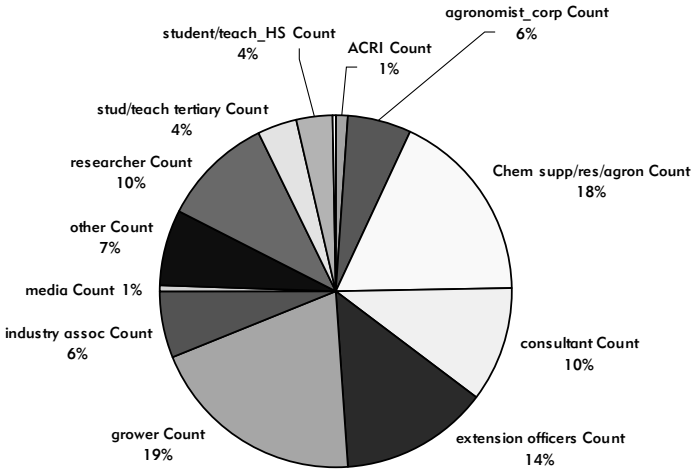


Figure 17. Breakdown of the "customers" for 540 queries to Technology Resource Centre during 2000-2001.



The TRC Coordinator, David Larsen, helps produce many of the publications, maintains the content of the website, liaises with individuals from industry and community seeking information, facilitates personal or group visits to the TRC, operates the mobile TRC for field days and other occasions, coordinates industry mailouts of an enormous volume of information, supports the many users of the *CottonLOGIC* computer-based decision support system, and participates in training workshops.

Table 8. Group contacts and regional visits for the mobile TRC.

TRC/*CottonLOGIC* workshops	Field days	Groups through the TRC	Conferences and trade shows
Goondiwindi Pittsworth Dalby Murgon Theodore Emerald St George Walgett Bourke Hillston Condobolin Trangie Warren Moree Narrabri Gunnedah	Namoi Goondiwindi Gwydir Dirranbandi Walgett Macquarie	■ Parkes farm management group ■ Qld Landcare group ■ GRDC group ■ US Researcher group ■ US Qld cotton group ■ WA Forest Industries group ■ "Women in Cotton" group	■ Australian Cotton Conference, Brisbane ■ Macquarie Food & Fibre, Warren ■ Australian Cotton Trade Show, Moree

Mobile Technology Resource Centre

Project Number: 4.3.1 AC

Developing Innovative Computer Based Technologies for Effective Delivery of Information and Cotton Management Decision Support

AIMS AND MILESTONES

The aims of the project are to:

- 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 website.

Milestones for Year 1 were to:

1. Maintain the functionality of the Cotton CRC's website.
2. Complete the handheld version of *CottonLOGIC*.
3. Help develop and deliver the Cotton Industry Database.
4. Complete a database providing CRC staff access to their information to enable changes to what is presented on the Cotton CRC's website.
5. 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.

STAFF

Dr Michael Bange, Senior Research Scientist, CSIRO Plant Industry
Ms Sandra Deutscher, Experimental Scientist Decision Support, CSIRO Plant Industry
Mr David Larsen, TRC Coordinator, NSW Agriculture
Mr Darren Linsley, Programmer, CSIRO Plant Industry
Mr Scott Johnston, Programmer, CSIRO Plant Industry
Mr Tony Pfeiffer, Computer Network Support Officer, CSIRO Plant Industry
Mr Dirk Richards, Experimental Scientist Agronomy and Cotton Model Application, CSIRO Plant Industry
Mr Stewart Whiteside, Programmer, CSIRO Plant Industry

PROGRESS

Progress against milestones is described in this section.

Maintain the functionality of the Cotton CRC's website.
Complete a database providing CRC staff access to their information to enable changes to what is presented on the Cotton CRC's website.

The reliability of, and access to, the Cotton CRC's website has been superb, with major advancements including the development of a secure staff database (changes in information accessed through a password); the industry having more reliable access and improvements to the cotton degree-day calculator accessed through the Cotton CRC website that accesses the Bureau of Meteorology's climate database (SILO project); a new homepage designed by CSIRO Plants Industry's Visual Resources Unit; and implementation of a new web address *www.cotton.crc.org.au*.

Complete the handheld version of CottonLOGIC

A prototype version of the *CottonLOGIC* software, as well as the software to enable the handheld to pass information to the PC desktop version of *CottonLOGIC*, has been completed. To date it appears that this level of development of such software has not

The CottonLOGIC Team - backrow Tony Pfeiffer, Dr Mick Bange, Scott Johnston and Tony Beale. Front row - Darren Lindsley, Dirk Richards, David Johnston, Mary Fielder, Stuart Whitside and Sandra Deutscher. David Larson missing

occurred elsewhere in the world. The present version is being assessed in northern Australia over the dry season, before a more thorough evaluation in the summer season 2001-2002. A formal release is planned for mid 2002.

Help develop and deliver the Cotton Industry Database

Significant effort was undertaken into scoping the needs of the Cotton CRC, Cotton Research and Development Corporation and Cotton Australia. A technical specification document was presented to the three parties outlining the tasks that need to be undertaken to implement sharing of information now and in the future. The implementation of these tasks has been postponed because of lack of resources and emphasis being placed on the completion of the handheld version of *CottonLOGIC*. The needs of the Cotton CRC have been, and are being met in relation to access to an industry database.

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

Following a review of the Cotton CRC website by relative participants, a clear purpose and boundaries were set for the type of information that would be delivered through it. Essentially the website is a primary mechanism to deliver outcomes of research, and a tool used for communication within the Cotton CRC. It was also decided that this message needs to be promoted more openly to avoid confusion on what the purpose of the website is. Following the completion and testing of the mechanism that enabled the staff database, the system is now fully implemented for the whole of the website to give more open use and frequent updating of information. The Cotton CRC website will be totally database driven by the end of the year.

There have been a number of other advances in computerised decision support.

***CottonLOGIC* release and development.** A major upgrade of *CottonLOGIC* (Version 4.0) was completed in late December 2000, and over 1100 registered copies were distributed. Version 4.0 included numerous enhancements and bug fixes with the major features being the development of a gross margin report, a cost/ha report, data recovery utilities, data exporting facilities, and enhancements to spray ordering forms.

User friendly *OZCOT* crop simulation model. After many years a simple but effective interface for the *OZCOT* crop simulation model has been developed. It includes capabilities to run the model for a single year for tactical crop management as well as for multiple years for strategic analyses. Simple graphing and data handling capabilities have also been included. Dirk Richards, with the help of Sandra Deutscher, conducted a 2-day workshop to instruct Cotton CRC extension personal in the responsible use of *OZCOT* and *CottonLOGIC*.

***HydroLOGIC*.** Significant planning has been conducted to enable development to begin on a water budgeting package as well as revitalising *HydroLOGIC* for irrigation management.

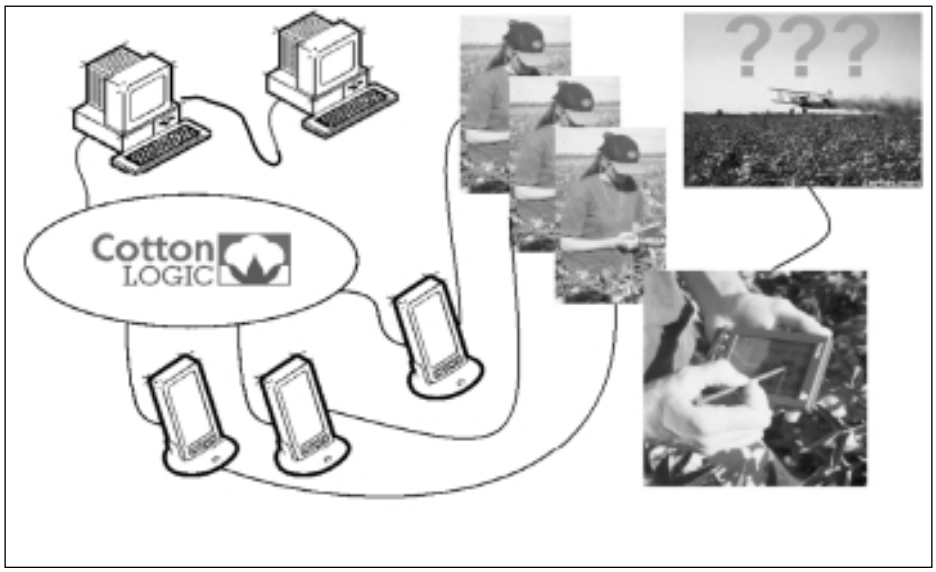
Workshop conducted by Cotton Logic *staff*

***CottonLOGIC* training and support.** The *CottonLOGIC* training workshops were held in August and September 2000. A total of seventeen workshops were conducted from as far north as Murgon in Queensland and south to Hillston in NSW. The new areas covered were Murgon and Condobolin. A total of 250 participants attended the workshops, which were similar figures to the 1999 workshops.

***CottonLOGIC* Steering Committee.** The Decision Support Steering Committee is made up of a range of industry stakeholder representatives to ensure that the industry has direct contribution to the development of decision support. Last year's meeting held in July 2000 focused on receiving feedback on the development of the handheld system, and validating experiments and outcomes from an independent evaluation of *CottonLOGIC*.

Field validation of *CottonLOGIC*. This year field validation of decision support conducted by Sandra Deutscher has again investigated the *NutriLOGIC* component of *CottonLOGIC* in cotton growing regions at Wee Waa, Myall Vale, Boggabri and Goondiwindi. Previous season's results showed that *NutriLOGIC* could be used effectively to manage nitrogen fertiliser. Another major component of field validation of *CottonLOGIC* has included Sandra's involvement in a large-scale field trial to explore *CottonLOGIC*'s role in achieving earliness in cotton.

A concept diagram showing the ability to download and collect information from multiple Palm® devices and the ability to make pest management decisions in the field using CottonLOGIC.



Program Five Cotton Textile Research

INTRODUCTION

In global textile markets, cotton is being replaced by synthetics on the basis of price, perceived quality and diversity of end uses. Loss of market share reduces returns to the cotton producer. The challenge of maintaining and growing cotton's market share, hence cotton producer profitability, must be met through:

- reducing costs and increasing quality
- establishing new products for cotton which are: superior or different or both, to those made from other fibres; recognised by the consumer as being superior; and seen by the consumer as environmentally-responsible and offering value for money.

Research and development in the area of cotton textile processing is required to meet these challenges. The Cotton Textile Research Unit (CTRU), based at CSIRO Textile and Fibre Technology (CTFT) in Geelong, is an integral part of the CRC and is focussed on a variety of issues in relation to the processing of Australian cotton. The capability already present in CTFT is being further enhanced through the establishment of a cotton spinning facility, which will now enable ginned fibre to be processed into woven and knitted fabrics. In conjunction with on-farm research, those attributes of the cotton fibre which are most important for processing performance as well as quality end-products will be identified quickly and communicated to industry. The ability to develop innovative cotton products will be further enhanced. A Centre of Excellence for Technical Textiles is also being set up in Geelong, enabling research to be carried out in non-apparel areas such as non-woven.

AIMS

The aims of Program Five are to:

- develop dyeing and bleaching technologies to support new products in cotton/wool blends
- reduce the environmental impact of cotton dyeing, bleaching and finishing
- 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
- enhance the ability of cotton fibres to compete, on the basis of costs and product versatility, with synthetic fibres.

HIGHLIGHTS AND ACHIEVEMENTS AGAINST MILESTONES

Major highlights and milestones have been:

1. Environmentally-friendly dyeing and bleaching technologies for cotton/wool blends being transferred to industry in both Australia and abroad.
2. An instrument for the analysis of white specs in dyed fabric is under development. This will be an important tool for on-going ginning and processing research into quality issues for Australian cotton.

LINKAGES

Linkages between CRC and CRDC-funded activities in the post harvest area, and the relationship with the National Centre for Engineering in Agriculture, have been further strengthened in the past 12 months. Relationships with cotton processors such as Rocklea and Bonds are continuing, and a linkage with China Dye (Hong Kong, one of Rocklea's international customers) is being formed. Contacts with the chemical companies, Ciba, Clariant and Warwick International, remain important. A strong association with USDA in New Orleans is being developed in relation to the instrumentation work.

Project Number: 5.1.0 AC

Innovative Bleaching Technology for Cotton and Cotton Blends

MILESTONES

Milestones for this project were as follows:

1. Laboratory development of a continuous bleaching process for cotton/wool blends.
2. Industrial evaluation of the process.
3. Preliminary investigation of low temperature bleaching of pure cotton completed.

STAFF

Dr David Evans, Principal Research Scientist, CSIRO Textiles and Fibre Technology
Dr Jackie Cai, Research Scientist, CSIRO Textile and Fibre Technology
Mrs Jill McDonnell, Technical Officer, CSIRO Textile and Fibre Technology

PROGRESS

A continuous (cold pad-batch) bleaching technology based on activated peroxide systems has been developed for cotton and cotton/wool blends. The new technology not only improves cotton bleaching, but also creates a new processing possibility for cotton/wool blends. Four bleaching trials on knitted cotton and cotton/wool blends were successfully completed at Bonds during November 2000. These trials proved the commercial feasibility of the new technology. Improved product quality (i.e. compared with conventional bleaching) is characterised by superior whiteness, handle and excellent cottonseed removal. Currently, bleaching trials on woven cotton/wool blends are being prepared for one of Rocklea's customers in Hong Kong (China Dye Holding Ltd). Rocklea and China Dye will provide cash and in-kind contributions for the trials.

Research on low temperature bleaching of cotton has been carried out this year. Three possible methods that are able to improve bleaching effectiveness at low temperatures have been identified. The application methods have shown good potential for improving cotton bleaching effectiveness and product quality. The preliminary study has also proved that it is feasible to achieve, at low temperatures, a whiteness equivalent to that obtained with a conventional high temperature process. Further development and mechanistic analyses are continuing.

To overcome the problems associated with the low solubility of TAED in water, we have developed a method that enables TAED to be dissolved quickly on site in the bleaching bath, and a liquid formulation that can be used more easily. A relationship is being established with Warwick International to pursue this development further.

Project Number: 5.2.0 AC

Continuous Dyeing of Cotton/Wool Blends

AIMS AND MILESTONES

The aim of this project is to develop continuous and semi-continuous procedures for the dyeing of cotton/wool blend fabrics.

Milestones for Year 2 were as follows:
1. Pilot scale trials of dyeing methods carried out with industrial partners.
2. Industrial scale evaluation of dyeing methods.
3. Preparation of information package for future technology transfer.

STAFF:

Dr David King, Senior Research Scientist, CSIRO Textile and Fibre Technology
Geni Kozdra, Technical Officer, CSIRO Textile and Fibre Technology

PROGRESS

Colana is a yarn produced by Rocklea Spinning Mills and is a blend of 70% Australian cotton with 30% Australian wool. This is a value-added product, and sales growth has been considerable. The methods developed for dyeing *Colana* have been restricted to exhaust methods involving pressurised machines and high temperatures. These methods are acceptable to some parts of the textile industry, but there is a more general need for fabric dyeing to use semi-continuous methods, such as cold pad/batch. These methods are more cost effective and lead to dyed fabric with different appearance and handle properties.

The aim of this project was to develop cold pad/batch methods for dyeing *Colana* and prove them in an industrial setting before transfer to the industry at large. Comprehensive methods have now been developed on a laboratory scale. Demonstration trials in industry have been carried out, and more are planned during May and June. Two companies plan to move to commercial production at the completion of these trials.

Project Number: 5.3.0 AC

Development, Manufacture and Commissioning of an Instrument for Computer Image Analysis of Dyed Cotton Fabric Visual Quality

AIM

The aim of this project is to develop, build and commission a computer controlled instrument for the evaluation of visual appearance of dyed cotton fabric with an emphasis on detecting undyed white specs.

STAFF

Dr Geoff Naylor, Senior Principal Research Scientist, CSIRO Textile and Fibre Technology

PROGRESS

Immature cotton fibres can lead to significant problems in dyed fabric where they show up as white undyed specs. At this late stage in processing, where a considerable amount of value adding has already taken place, this can represent a significant cost to the industry.

The instrument will form part of a research facility in Australia to process small batches of cotton through the textile pipeline to knitted and woven samples and to analyse final fabric quality. This research facility will then be used to evaluate the impact of Australian cotton fibre quality characteristics on fabric quality and for optimising ginning and textile processing parameters for Australian cotton. It is to be developed

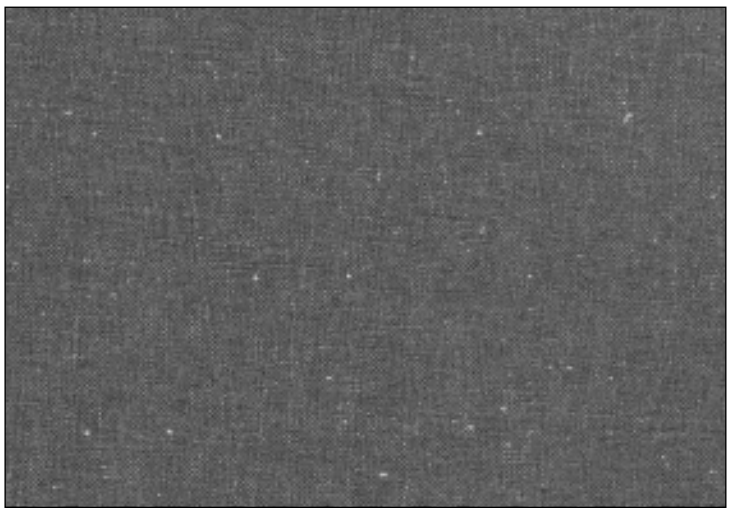
cooperatively by the National Centre for Engineering in Agriculture (NCEA) in Toowoomba and CSIRO Textile and Fibre Technology.

Contact has been made with a researcher at the US Department of Agriculture in New Orleans who has a similar instrument. Following extensive discussions it has been decided to essentially copy the US instrument rather than 'reinvent the wheel'. This has many potential advantages including the following:

- a head start in the development of the machine
- access to pre-measured samples for calibrating the new instrument
- compatibility of results between the two laboratories
- compatibility of results with existing historical data from the US instrument.

Unfortunately there was an unexpected delay due to the ill-health of the US researcher. For this reason the project is running behind schedule and has been carried over to the 2001-2002 financial year.

An example of white specs in dyed fabric.



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3.1.02 **Rochester I.J, Peoples M.B and Constable GA** (2001). Estimation of the N fertilizer requirement of cotton grown after legume crops. *Field Crops Research* **70**: 43-53.

3.1.02 **Rochester I.J, Peoples M.B, Hulugalle N.R, Gault R.R and Constable G.A** (2001). Using legumes to enhance nitrogen fertility and soil condition in cotton cropping systems. *Field Crops Research* **70**: 27-41.

3.1.03 **Milroy, S.P., Bange, M.P. and Sadras, V.O.** (2000). Profiles of Leaf Nitrogen and Light in Reproductive Canopies of Cotton (*Gossypium hirsutum*). *Annals of Botany.* 87(3): 325-333.

3.1.11 **McBratney A.B., Odeh, I.O.A., Bishop, T.F.A., Dunbar, M.S. and Shatar, T.M.** (2000). An overview of pedometric techniques for use in soil survey. *Geoderma* 293-327.

3.1.11 **Odeh, I.O.A., and McBratney A.B**. 2000. Using AVHRR images for spatial prediction of clay content in the lower Namoi Valley of eastern Australia. *Geoderma* 237-254.

3.2.00 **J. Triantafilis, I.O.A. Odeh and A.B. McBratney.** (2001). Five geostatistical models to predict soil salinity from electromagnetic induction data across irrigated cotton. *Soil Science Society of America Journal,* 65:869-878.

3.2.00 **J. Triantafilis, W.T. Ward and A.B. McBratney** (2001). Continuous land suitability assessment in the lower Namoi Valley, NSW Australia. *Australian Journal of Soil Research* 39:273-289.

3.2.00 **J. Triantafilis, W.T. Ward, I.O. A. Odeh and A.B. McBratney.** (2001). Creation and interpolation of soil layer classes in the lower Namoi Valley. *Soil Science Society of America Journal* 65:403-413.

CONFERENCE PAPERS

2.2.05 **S. Bentley, J.K. Kochman, N.Y. Moore, J.A. Pattemore, L. Gulino, and W.T. O'Neill.** (2000). DNA diagnostics for *fusarium* wilt of cotton. Poster presented at the *10th Australian Cotton Conference*, Brisbane, Queensland, 16-18 March, 2000. Pages 455-461

2.2.13 **Kvedaras O.L, P.C Gregg, A.P Del Socorro & C. Moore** (2000) The influence of host plants on the mating behaviour of *Helicoverpa armigera*. *The Cotton CRC Research Conference, Narrabri.*

2.2.13 **Kvedaras O.L, P.C Gregg, AP Del Socorro, D Alter & C Moore** (1999) The response of the cotton bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) to host plant volatiles. *Australian Entomological Society 30th AGM and Scientific Conference, 'Insects in the Australian Environment'*, Canberra. CD Rom.

3.1.00 **Hulugalle, N.R., Entwistle, P.C., Weaver, T., Scott, F., and Finlay, L.A.** (2000). Soil quality and profitability in a sodic, grey clay in Merah North, NSW, due to sowing rotation crops and applying gypsum. *Proc. 10th Australian Cotton Conference*, 16-18 August 2000, Brisbane, Qld., Australia, pp. 301-307. (Australian Cotton Grower's Research Association, Orange, NSW, Australia).

3.1.00 **Hulugalle, N.R., Nehl, D.B., Weaver, T., Finlay, L.A., Tennakoon, S., and. Tann, C.** (2000). Effect of tillage system and wheat rotation crop on soil properties, cotton disease and pest incidence, water use and growth in a Vertisol after winter flooding. *Proc. 15th Conference of International Soil Tillage Organization*, 2-7 July 2000, Fort Worth, TX, USA, Ed. J.E. Morrisson, Jr. (Texas Agricultural Experimental Station/USDA-ARS, Temple, TX, USA). CD ROM

3.1.00 **Rohde, K., Hulugalle, N.R., Yule, D., Entwistle, P.C., Weaver, T., and Finlay, L.A.** (2000). Bed width and cropping system effects on soil properties, runoff and erosion in a rainfed Vertisol. Proc. *15th Conference of International Soil Tillage Organization*, 2-7 July 2000, Fort Worth, TX, USA, Ed. J.E. Morrisson, Jr. (Texas Agricultural Experimental Station/USDA-ARS, Temple, TX, USA). CD ROM

3.1.02 **Dorahy, C.G., Rochester, I.J. and Blair, G.J.** (2000). Improving phosphorus (P) fertiliser decisions for cotton. *Proceedings of the 10th Australian Cotton Conference*, Brisbane, Qld. Aug 16-18, 2000, Australian Cotton Growers' Research Association. pp. 277-281.

3.1.02 **Rochester I.J, Constable G.A, Peoples M.B.** (2000) 'Monitoring cotton nutrition'. *10th Australian Cotton Conference*. (Brisbane, 2000) pp 283-287.

3.1.07 **Richards, Q.D., Bange, M.P. and Roberts, G.N**. (2001) Assessing the risk of 'earliness management strategies within the Australian cotton industry. *Proc. 10th Australian Agronomy Conference* Jan 28 - Feb 1, Hobart, Tasmania. CD Rom

3.1.07 **Roberts, G.N. and Constable, G.A.** (2001). Examining 'earliness' systems for cotton production. *Proc. 10th Australian Agronomy Conference*, Jan 28 - Feb 1, Hobart, Tasmania, 2001. CD Rom

3.1.07 **Roberts, G.N.** (2000). The agronomy of complex farming systems. *Proc. 10th Australian Cotton Conference*. 16th-18th August, Brisbane, pp 253-259.

3.1.08 **Bentley, S., Kochman, J.K., Moore, N.Y., Pattemore, J.A., Gulino, L.M. and O'Neill, W.T**. "DNA Diagnostics for *Fusarium* wilt of cotton". Paper in proceedings of the *10th Australian Cotton Conference*, Brisbane, 16-18 August 2000. Pages 445-461

3.1.08 **Kochman, J.K., Moore, N.Y., Obst, N.R., O'Neill, W.T., Salmond, G. and Bentley, S.** "Management strategies for *Fusarium* wilt of cotton". Invited paper, *10th Australian Cotton Conference, Brisbane,* 16-18 August 2000. Pages 443-453.

3.1.11 **B. Singh, I. O. A. Odeh and A.B. McBratney.** (2000). Buffering capacity and acidification rates of cotton soils in northern NSW. Proceedings of the *10th Australian Cotton Conference*— Meeting the Challenge. 16th – 18th August, 2000. ACGRA, Orange, NSW 2800. pp705-711.

3.1.11 **Dunbar, M.S. and Odeh, I.O.A.** (2000). Factorial kriging as a filter of satellite digital data for regional soil inventory. In *Soil 2000: New Horizons for a New Century. Australian and New Zealand Second Joint Soils Conference*. Volume 2: Oral Papers. Eds. J.A.

Adams and A.K. Metherell. 3-8 December 2000, Lincoln University. New Zealand Society of Soil Science. Pp93-4.

3.1.11 **O.A. Odeh, B. Figueroa and A.B. McBratney.** (2000). Soil fertility indicators for the cotton-growing region of the lower Namoi valley. *Proceedings of the 10th Australian Cotton Conference— Meeting the Challenge*. 16th – 18th August, 2000. ACGRA, Orange, NSW 2800. pp297-300.

3.1.11 **Warr, B. and Odeh I.O.A.** (2000). Geostatistical estimation of soft pedological data. *Proceedings of the Australian and New Zealand Second Joint Soils Conference*, December 3-8 2000. Lincoln University, New Zealand. Pp 219-220.

3.2.00 **J. Triantafilis** (2000). Use of EM instruments to describe spatial distribution of soil properties: experiences in Australian cotton fields. EM38 Workshop Proceedings, New Delhi. *ILRI Special Report No. 10*, pgs. 69-76.

3.2.00 **J. Triantafilis, M.F. Ahmed and A.I. Huckel** (2000). Use of a Mobile EM Sensing System for improved natural resource management at the fieldscale. Proceedings of the 10th Australian Cotton Growers Research Association Conference, Brisbane Convention Centre, August 16-18. pp 379-386.

4.2.06 **Hoque Z, Dillon M, Farquharson B and Kauter G.** (2001) "Modelling and evaluating alternative management strategies for insecticide resistance in the Australian cotton industry". *In Proceedings of the 45th Annual Conference of the Australian Agriculture and Resource Economic Society*, Adelaide, 23-25 January 2001. CD ROM

4.3.01 **Bange, M.P., Deutscher, S.A., Plummer, C., Larsen, D., Linsley, D., Richards, D. and Whiteside, S.** (2000). Crop models and decision support – Future developments and applications. *In Proc. 10th Aust. Cotton Conf.* 16-18 August, Brisbane Aust., pp. 629-637.

4.3.01 **Deutscher, S.A. (2000).** Validation and Calibration of *NutriLOGIC*. In Proc. 10th Aust. *Cotton Conf.* 16-18 August, Brisbane Aust., pp. 315- 319.

5.1.00 **J.Y. Cai, D.J. Evans and S.M. Smith,** "Bleaching of Cotton and Cotton/Wool Blends with NOBS and TARD Activated Peroxide Systems", 2000 AATCC International Conference & Exhibition, N.C. USA, Sept. 2000. Pages 569-574.

5.1.00 **J.Y.Cai,** "Bleaching of Woven Cotton/Wool Blends with A Jig Machine", *10th Australia Cotton Conference*, Aug. 2000 pages 134-143

5.3.01 **Dorahy, C.G., Rochester, I.J. and Blair, G.J.** (1998) Determination of the critical soil and plant phosphorus levels for cotton. *Proceedings of the 9th Australian Cotton Conference*, Broadbeach, Qld. Aug 12-14, 1998, Australian Cotton Growers' Research Association. pp. 165-169.

BOOK CHAPTERS

2.1.01 **Fitt, G.P.** (2001). Deployment and impact of transgenic Bt cottons in Australia. In *Global impacts of biotechnology*, Kluwer (in press).

2.1.01 **Fitt, G.P. and Wilson, L.J.** (2000) Genetic Engineering in IPM: Bt cotton. pp. 108-125 In: Kennedy, G.G. and Sutton, T.B. (eds). *Emerging Technologies in Integrated Pest Management: Concepts, Research and Implementation*. APS Press, St. Paul.

2.2.16 **Johnson, M.-L., Pearce, S., Wade M., Davies A., Silberbauer L., Gregg P. and Zalucki M.** (2000). *Review of natural enemies in cotton farming systems*. Review commissioned by the Cotton Research and Development Corporation. CRDC, Narrabri, 79pp.

3.1.11 **Odeh I.O.A. and A.B. McBratney** (2001). Newer application techniques– fuzzy sets. In: *Methods of Soil Analysis*. American Society of Agronomy (In press).

3.1.11 **T.F.A Bishop and I.O.A. Odeh.** (2001). The role of geographic information systems in catchment scale soil studies.Chapter 22, pp361-384. In S Cattle and & B. George (Eds), *Soil Technology – Applied Soil Science (1st edition)*, Australian Society of Soil Science, NSW Branch, & University of Sydney. pp 416

THESES

3.1.11 **Cregan, T.M.** (2000). The use of remote sensing and GIS in updating soil resource information in St George cotton-growing region. Honours thesis, The University of Sydney.

3.1.07 **Sam Duddy,** (2000) CRC funded summer scholarship achieved 1st Class honours on completion of his thesis titled 'The agronomics and economics of managing cotton for earliness'.

RESEARCH REFERENCE REPORTS

Aug-00 "A Tractor Drivers View of *Fusarium* Wilt" Single Page Brochure

Mar-01 **Kerrily Rourke and David Nehl** "Black Root Rot Update"

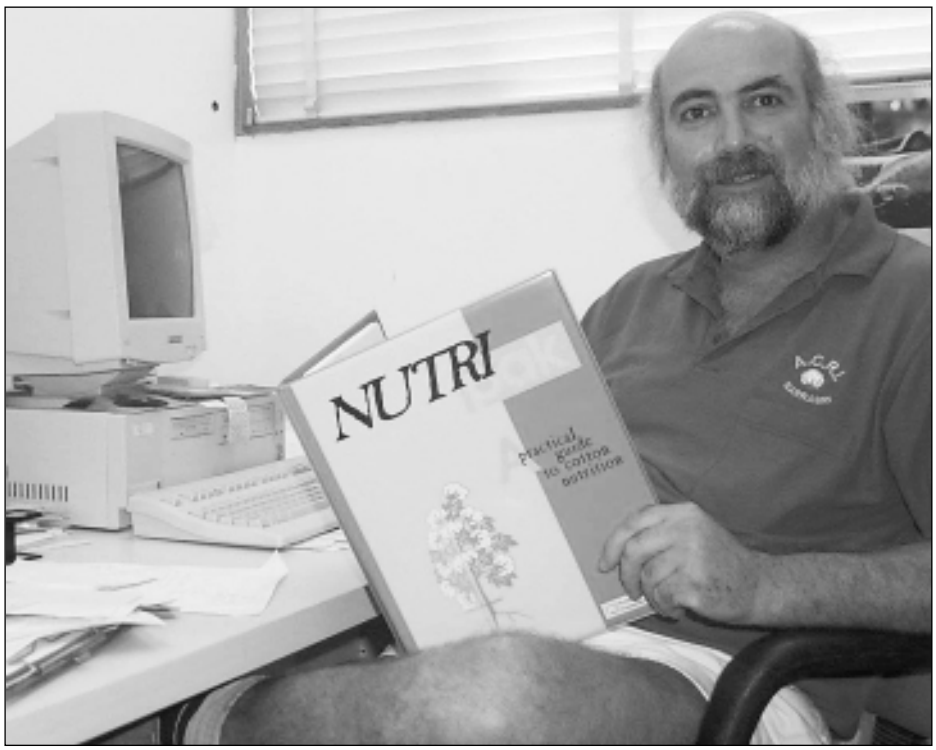
May-01 **David Kelly & David Waters** "Planting Cotton Into Standing Wheat Stubble"

May-01 **David Nehl** "Soilborne disease - don't shoot yourself in the foot!"

May-01 **Julie Ferguson, Melinda Miles, David Murray, Martin Dillon, Greg Kauter and Richard Lloyd** "Spring Trap Crop Management Guidelines"

May-01 **Lewis Wilson, Grant Herron** "Aphid Resistance Management"

3.1.02 **Rochester I.J, Rea M, Dorahy C, Constable G.A, Wright P, Deutscher S, Thongbai P and Larsen D** (2001). *NUTRIpak* – a practical guide to cotton nutrition. Australian Cotton CRC. CSIRO Publishing.



Dr Ian Rochester with NUTRIpac, the final product.

Public presentations, Public relations & Communications

CONFERENCE PRESENTATIONS:

1.2.04 **R.W. Vervoort and S.R. Cattle** Quantification of Hydrological and Structural Relationships in Vertisols,. Amercian Society of Agronomy meetings, Nov. 5 – 9, 2001 Minneapolis MN.

1.2.04 **R.W. Vervoort, S.R. Cattle and D.S. Murray** - Quantification of hydrological and soil structural relationships in three cotton management systems, Proc. of the NZSS/ASSSI meeting. Dec 3 – 8, 2000 Christchurch. NZ.

2.1.01 **Fitt G.P. and R Leonard,** "IPM in cotton: the challenge of integrating new tools to minimise pesticide dependence". Invited Symposium paper, XXI International Congress of Entomology, Brazil, August 2000.

2.1.01 **Fitt, G,P. and R.T. Roush,** "Development And Implementation Of Resistance Management Strategies For Bt Cotton In Australia". Invited Symposium paper, XXI International Congress of Entomology, Brazil, August 2000.

2.1.01 **Fitt, G.P.** "A future for IPM in cotton: the challenge of integrating new tools to minimise pesticide dependence. " International Cotton Advisory Committee Conference, Cairns, November 2000

2.1.01 **Fitt, G.P.** "IPM with two gene cotton". Australian Cotton Research Conference, August 2000.

2.1.01 **Fitt, G.P. and Dillon, M.** "Cropping Patterns. A Landscape Perspective Of Cultural Control". Invited Symposium paper, XXI International Congress of Entomology, Brazil, August 2000.

2.1.01 **Fitt, G.P., Constable G.C.** "Towards Clean, Green Cotton", International Cotton Advisory Committee Conference, Cairns, November 2000

2.1.01 **Wilson, L.J. and Fitt G.P.,** "Non-Target Effects Of Bt-Cotton: A Case Study From Australia". Invited Symposium paper, XXI International Congress of Entomology, Brazil, August 2000.

2.2.03 **Britton, D. and Gregg, P.** (2000) Attractive from a distance, but up close, not so good…. Developing attract and kill lures to control the cotton bollworm *Helicoverpa armigera*. *Australian Entomological Society, 31st Scientific Conference and A.G.M., Darwin*. Oral presentation and abstract written in proceedings.

2.2.03 **Britton,D., Gregg,P. and Del Socorro, A.** (2000) Attract and kill formulations for *helicoverpa armigera* males (Lepdioptera: Noctuidae*). Proceedings of the Farming Systems Forum, Dalby, 5-6 December 2000*. Cotton Research and Development Corporation, Narrabri. Oral presentation and abstract written in proceedings.

2.2.03 **Del Socorro,A.P., and Gregg,P.C.** (2000) Pollen as a marker for long-distance migration and local movement of *Helicoverpa* moths in Australia. *Proceedings of the XXI International Congress of Entomology, Iguassu Falls, Brazil, 20-26 August 2000. A168* Oral presentation and abstract written in proceedings.

2.2.03 **Gregg,P.C.** (2000) Distant native hosts in semi-arid regions as a source of pest infestations in cropping regions: the Australian experience. *Proceedings of the XXI International Congress of Entomology, Iguassu Falls, Brazil, 20-26 August 2000. A140 Oral presentation and abstract written in proceedings.*

2.2.03 **Kvedaras,O.L., Gregg,P.C., Del Socorro,A.P., Alter,D. and Moore,C.** (2000) The effects of host plant odours on the calling behaviour , egg maturation and mating success of the cotton bollworm, *Helicoverpa armigera* (Lepidoptera: Noctuidae). *Proceedings of the XXI International Congress of Entomology, Iguassu Falls, Brazil, 20-26 August 2000. A687* this is conference publication or presentation ??

2.2.05 **J. Kochman, N.Y. Moore, N. Obst, W.T. O'Neill, G. Salmond, S. Bentley.** 2000. Management strategies for *fusarium* wilt of cotton. Paper presented at the 10th Australian Cotton Conference, Brisbane, Queensland, 16-18 March, 2000.

2.2.05 **L.M. Gulino, S. Bentley, J.A. Pattemore, N.Y, Moore, J.K. Kochman** 2001. Development of a DNA based assay for detection of *fusarium* wilt of cotton. Poster presented at the 2nd Australasian Soilborne Diseases Symposium, Lorne, Victoria, 5-8 March, 2001.

2.2.05 **L.M.Gulino, S. Bentley, J.A.Pattemore, N.Y. Moore, J.K. Kochman** 2001. Development of a DNA based assay for detection of *Fusarium* wilt of cotton. Poster presented at the 2nd Australiasian Soilborne Diseases Symposium., Lorne, Victoria, 5-8 March,2001.

2.2.16 **Silberbauer, L.** December 2000 Investigating ecological services from generalist predators in cotton. Ecology Society of Australia Conference, Melbourne, Vic. Spoken presentation

2.2.16 **Silberbauer, L., Gregg, P. and Reid, N.** (2000) Investigating ecological services from generalist predators in cotton. Ecology Society of Australia Conference, Melbourne, Vic.

3.1.00 **Hulugalle** – Two poster papers presented at 10th Australian Cotton Conference, 16-18th August,2000, Brisbane, QLD., Australia.

3.1.00 **Hulugalle** – Two poster papers presented at 15th Conference International soil Tillage Organization,2-7 July 2000, Fort Worth,TX, USA.

3.1.03 **D. Richards** gave a presentation at the 10th Australian Agronomy Conference. Hobart. January 30 - February 1, 2001 on assessing the risk of cotton 'earliness' management strategies with crop simulation.

3.1.03 **M. Bange** gave a presentation at the 10th Australian Agronomy Conference. Hobart. January 30 - February 1, 2001 on the effect of temperature on the rate of early fruiting developmental processes of cotton.

3.1.03 **M. Bange** was invited to speak on decision support and crop simulation models at the Tenth Australian Cotton Conference.

3.1.03 **P. Thongbai** gave a presentation at the 10th Australian Agronomy Conference. Hobart. January 30 - February 1, 2001 on the Agronomic Response of Cotton to Low Soil Oxygen during Waterlogging.

3.1.03 **S. Milroy** gave a presentation at the 10th Australian Agronomy Conference. Hobart. January 30 - February 1, 2001 on fruit production rates in cotton cultivars of different maturity times.

3.1.03 **S. Milroy** was invited to speak on water use efficiency at Tenth Australian Cotton Conference.

3.1.07 **Roberts, G.N. and Constable, G.C.** (2001). "Examining 'earliness' systems for cotton production". *Proceedings of the 10th Australian Agronomy Conference*, Hobart 28 January - 1 February.

3.1.08 **Dr Joe Kochman and Dr Natalie Moore** delivered an invited paper on *Fusarium* wilt research at the 10th Australian Cotton Conference, Brisbane, 16-18 August 2000 "DNA Diagnostis for *fusarium* wilt of cotton".

3.1.08 **Gulino, L.M., Bentley, S., Pattemore, J.A., Moore, N.Y. and Kochman, J.K.** "Development of a DNA based assay for detection of *Fusarium* wilt of cotton", Poster presentation at the Second Australian Soilborne Diseases Symposium, Lorne, Victoria 2-5 March 2001

3.1.08 **O'Neill, W.T. and Moore, N.Y.** "*Fusarium* wilt of cotton: Diagnosis and distribution in Australia" Poster presentation at the 10th Australian Cotton Conference, Brisbane, 16-18 August 2000

3.1.08 **S. Bentley, J.K. Kochman, N.Y. Moore, J.A. Pattermore, L. Gulino and W.T. O'Neill** "DNA diagnostics for *Fusarium* wilt of cotton", Poster presentation at the 10th Australian Cotton Conference, Brisbane, 16-18 August 2000

3.1.11 **I.O.A. Odeh.** 2000. Simulation of soil carbon dynamics under different farming systems in NW NSW, Australia. Presented at the Workshop on "Soil Carbon and Greenhouse Gas Emissions". Australian and New Zealand Second Joint Soils Conference, December 3-8 2000. Lincoln University, New Zealand.

3.2.02 **L. Silberbauer, P.Gregg and N. Reid.** Dec. 2000 Ecology Society of Aust. Conference, Melbourne,"Investigating ecological services from generalist predators in cotton" Oral presentation only

4.2.04 **Kauter, G.** IPM – Sticking to the Challenge. 10thAustralian Cotton Conference, the Australian Cotton Growers Research Association, Brisbane, Queensland, August 16 – 18.

4.2.04 **Kauter, Greg** (2000), IPM Sticking to the Challenge. In Proceedings of the 10thAustralian Cotton Conference, the Australian Cotton Growers Research Association, Brisbane, Queensland, August 16 – 18.

4.2.04 **Kauter, Greg, Gibb, Dallas and McIntyre, Geoff** (2000), Australian Cotton Cooperative Research Centre IPM Short Course – 'learning together'. In Proceedings of the 10thAustralian Cotton Conference, the Australian Cotton Growers Research Association, Brisbane, Queensland, August 16 – 18.

4.2.06 **Dillon, Martin and Hoque, Ziaul** (2000), "An analysis of pest pressure in an area wide management group". In Proceedings of the 10th Australian Cotton Conference, The Australian Cotton Growers' Research Association, Brisbane, Queensland, August 16 -18.

4.2.06 **Hoque Z, Dillon M, Farquharson B and Kauter G.** 2001 "Modelling and evaluating alternative management strategies for insecticide resistance in the Australian cotton industry". In Proceedings of the 45th Annual Conference of the Australian Agriculture and Resource Economic Society, Adelaide, 23-25 January 2001.

4.2.06 **Hoque Z, Farquharson B, Dillon M and Kauter G.** 2000, An economic evaluation of an on-going IPM program within the Australian Cotton Industry. In Proceedings of the 10th Australian Cotton Conference, The Australian Cotton Growers' Research Association, Brisbane, Queensland, August 16 -18.

4.3.00 **David Larsen** - Macquarie Food & Fibre, Warren CRC display and Technology Resource Centre promotion,

4.3.01 **Deutscher, S.A. (2000)** Useful Internet Sites. 10th Aust. Cotton Conference, 16-18 August, Brisbane Aust. Women in Agriculture session

4.3.01 **Deutscher, S.A., Bange, M.P. and Rochester, I.** (2001). Testing *NutriLOGIC*, a decision aid for nitrogen fertiliser management in Cotton. Proceedings of the 10th Australian Agronomy Conference, Hobart, TAS. 2001.

5.1.00 **J. Cai** - A presentation on innovative bleaching technology was given at 2000 AATCC International Conference & Exhibition, N.C. USA, September 2000**.**

5.1.00 **JY. Cai, D. J. Evans and S. M. Smith,** *2000 AATCC International Conference & Exhibition, N.C. USA, Sep. 2000. CD ROM*

5.3.01 **Dorahy, C.G., Blair, G.J. and Rochester, I.J.** (1999). "To P or not to P? - That is the question!" *The Cotton CRC Research Conference*. 21-22 July 1999, Narrabri, NSW.

5.3.01 **Dorahy, C.G., Rochester, I.J. and Blair, G.J.** (2000). "Improving P fertiliser decisions for cotton". *The 10th Australian Cotton Conference*. 16-17 August 2000, Brisbane, Qld.

SEMINARS & WORKSHOPS

1.1.01 **S. Yeates** - November 2000, Darwin – Joint WA / NT Review and Planning meeting - Responsible cotton production systems in Northern Australia.

1.1.01 **S. Yeates** - June 2000, Narrabri - Cotton CRC Annual Review - Responsible cotton production systems for Northern Australia.

1.1.01 **S. Yeates** - March 2001, Kununurra – Presentation of results to Farmers and other Collaborators - Responsible Farming systems for Northern Australia.

1.1.01 **S. Yeates** - May 2001, Richmond – Invited presentation at Field day and Community Forum - Responsible Farming systems for Northern Australia.

1.4.02 **Dr Ian Titmarsh** - 14-15 November 2000 Address to meeting of Southern Gulf Catchments Group, Julia Creek - Cotton Production Systems in Northern Australia.

1.4.02 **Dr Ian Titmarsh** address to SGCG-sponsored public forum on water developments for the Flinders River - part of the Farming Diversification Expo & Field Days, 3-4 May 2001, Richmond DPI QLD

1.4.02 **Ian Titmarsh** - Public Forum on GM Cottin in Nth Qld, Richmond, May 3/4- presentation. DPI QLD - Cotton Production systems for cotton in Northern Queensland.

2.1.01 **Fitt, G.** - Insecticide Resistance Management Strategy meetings. Nine meetings in different cotton regions, June 12-15, 2001.

2.2.03 **Del Socorro, A.** *Developing attractants for Helicoverpa armigera moths.* Seminar presented at the Biological and Ecological Chemistry Department, IACR-Rothamsted, UK; Department of Ecology, Lund University, Lund, Sweden; and Department of Chemical Ecology, Göteborg University, Göteborg, Sweden, August 2000.

2.2.03	**Gregg,P.** (2000) *Early warning on punctigera build-up*. Video segment on Cotton World, Issue 7, Spring 2000. Cotton Communications Pty Ltd, Toowoomba.
2.2.03	**Gregg,P.** Spring forecasts for *Helicoverpa* spp. Radio interviews, 2VM, 2WEB, ABC Rural Radio, August 2000.
2.2.03	**Gregg,P.C**. *Ecology of migratory pests in inland Australia*. Seminar presented at the Biological and Ecological Chemistry Department, IACR-Rothamsted, UK; Department of Ecology, Lund University, Lund, Sweden; and Department of Chemical Ecology, Göteborg University, Göteborg, Sweden, August 2000.
3.1.00	**Hulugalle** presentation during field tour of CRC/CRDC Farming Systems Forum, -6 December 2000, Dalby, QLD., on soil management issues and changes in soil quality at the CRC farming systems experiment at "Prospect", Warra, due to sowing rotation crops.
3.1.00	**Hulugalle** presentation on (a) C sequestration in cotton-based farming(experimental results) and (b) proposal on root dynamics and soil C sequestration at workshop held on 04/09/2000 between Australian Cotton CRC, Greenhouse Gas CRC and AGO pn greenhouse gas emissions and possible joint projects.
3.1.00	**Hulugalle** presentation to Australian Cotton CRC Soil Workshop on 23/06/2000 on soil carbon sequestration and global warming issues.
3.1.00	**N.R Hulugalle** - Presentation by to Australian Cotton CRC Soil Workshop on 23/6/2000 on soil carbon sequestration and global warming issues.
3.1.00	**N.R Hulugalle** - Presentations by on (a) C sequestration in cotton-based farming systems (experimental results) and (b) proposal on root dynamics and soil C sequestration at workshop held on 4/9/2000 between Australian Cotton CRC, Greenhouse Gas CRC and AGO on greenhouse gas emissions and possible joint projects.
3.1.00	**N.R Hulugulle** - Presentation by during field tour of CRC/CRDC Farming Systems Forum, 5-6 December 2000, Dalby, Qld., on soil management issues and changes in soil quality at the CRC's farming systems experiment at "Prospect", Warra, due to sowing rotation crops.
3.1.02	**Ian Rochester** - Lectures by to CRC Cotton Production Course students (22/05/00 and 29/05/01) - Nutritional stresses on cotton crops.
3.1.02	**Ian Rochester** - Presentation of Nutritional stresses in cotton to the Australian Cotton CRC Review (21/6/00)
3.1.02	**Ian Rochester** - Presentation of Nutritional stresses in cotton to the Cropping Systems Forum (Dalby - 7/12/00)
3.1.02	**Ian Rochester** - Presentation of Nutritional stresses in cotton to the CSD/CSIRO Research Review (1/6/00)
3.1.02	**Ian Rochester** - Presentation of Nutritional stresses in cotton to the Grower meeting (Wee Waa – 9/8/00)
3.1.02	**Ian Rochester** - Presentation of Nutritional stresses in cotton to the Mallawa cotton growers (Field Day – 28/8/00)
3.1.02	**Ian Rochester** - Presentation of Nutritional Stresses in cotton to the Namoi cotton growers (Field Day - 16/3/01)
3.1.02	**Ian Rochester** - Presentation to UNR cotton growers at Griffith UNR conference (6/3/01)
3.1.02	**Ian Rochester** - Presentations Nutritional stresses in cotton to the MacIntyre growers (Field Day - 28/2/01)
3.1.03	**M. Bange** was invited to participate in workshop reviewing the future direction of the Agricultural Production Systems Research Unit based in Queensland - Integration of agronomy, crop physiology and modelling research capabilities.
3.1.03	**M. Bange** was invited to participate in workshop reviewing the use of crop simulation modelling and farming systems research with agribusiness and APSRU - Integration of agronomy, crop physiology and modelling research capabilities.
3.1.03	**P. Thongbai,** gave a presentation at CRDC/CRC Farming Systems Forum, 5&6 December 2000, Dalby, Qld. on Waterlogging and its effect on cotton growth and yield.
3.1.03	**S. Milroy** gave a presentation at CRDC/CRC Farming Systems Forum, 5&6 December 2000, Dalby, Qld. on a Review of Water Research.

3.1.03 **S. Milroy** gave a presentation at CRDC/CRC Farming Systems Forum, 5&6 December 2000, Dalby, Qld. on progress in Cotton Modelling.

3.1.03 **S. Milroy** gave a presentation at the CSD/CSIRO Research Review (consultants and growers) 1 June 2000, Narrabri, NSW on *OZCOT*, Current Developments.

3.1.05 **Dr Ian Taylor** - Walgett Field day - Sustainable weed management systems in cotton.

3.1.05 **Dr Ian Taylor** - Weeds forum CCA (Dalby) - Sustainable weed management systems in cotton.

3.1.06 **Dr Scott Hardwick** attended three meetings with cotton growers from the Hillston region and representatives of NSW Agric. to discussions issues relating to insecticide resistance in the Hillston region.

3.1.06 **Dr Scott Hardwick p**resented a seminar in the CSIRO Land and Water (Griffith) seminar series titled "The development of a regional IPM strategy for the control of *Helicoverpa* in southern NSW and northern Victoria" 18/4/01

3.1.07 **Grant Roberts** - Oral presentations on Integrated Weed Management at both the McIntyre Valley and Macquarie Valley field days.

3.1.07 **Grant Roberts** presentation at the 10th Australian Cotton Growers Research Conference, Brisbane August 16-18th on 'The agronomy of complex farming systems'.

3.1.07 **Grant Roberts** presented at the CRDC Farming systems forum at Dalby 5th-6th on the topic of 'Farming Systems Experimentation – Cotton CRC.'

3.1.07 **Grant Roberts** presented Earliness management strategies seminar at Cotton Seed Distributors research forum for cotton consultants. May 11th, Narrabri.

3.1.07 **Grant Roberts** presented Roundup Ready Cotton seminar at Cotton consultants research forum for cotton consultants. May 10th, Narrabri.

3.1.08 **Dr Joe Kochman** - Cotton CRC/ACGRA *Fusarium* wilt workshop held in Goondiwindi on 6th February 2001 - Management Strategies for *Fusarium* Wilt.

3.1.08 **Dr Joe Kochman** - CRDC workshop, Dalby 5th & 6th December 2000 - Management strategies for *Fusarium* wilt.

3.1.08 **Dr JoeKochman** - Project staff have contributed to grower and industry meetings held in Norwin, Dalby, Toowoomba, St George, Goondiwindi and Emerald during the reporting period - Management strategies for *fusarium* wilt.

3.1.08 **Lisa Gulino** attended the Cotton CRC Postgraduate Visit, Narrabri, Thursday 26th April - Friday 27th April: Oral Presentation "Molecular Characterisation and Detection of *Fusarium oxysporum* f.sp. *vasinfectum*"

3.1.08 **Lisa Gulino** was invited to present a seminar for the DPI and Australasian Plant Pathology Society seminar series held at DPI, Indooroopilly, 23rd February 2001. Oral Presentation "Molecular characterisation and detection of *Fusarium oxysporum* f.sp. *vasinfectum*"

3.1.11 **I.O.A. Odeh.** 2000. Attended: Carbon Sinks Workshop. September 8-10, 2000. CRC for Greenhouse Accounting, Research School of Biological Sciences, ANU Canberra, ACT 2606.

3.2.02 **N. Reid and D. Thompson**. - March 2001 National Ecosystem Services Modelling Workshop, Atherton Qld. Spoken presentation "Nature and Value of Ecosystem Services in the Gwydir Catchment"

3.2.06 **Janelle Montgomery.** - Natural Heritage Trust project review conducted by North West Catchment Management Committee, March 1999, March 2000 - Environmental impact of irrigation in the Gwydir Valley.

3.2.06 **Janelle Montgomery**. - Progress report contained in the Australian Cotton CRC Annual Report, 1998-99, 1999-01 - Environmental impact of irrigation in the Gwydir Valley.

3.2.06 **Janelle Montgomery**. - Seminar presented at The Australian Cotton CRC, June 2000 - Environmental Impact of irrigation in the Gwydir Valley.

3.2.06 **Janelle Montgomery.** - Seminar presented to Steering Committee and members of the Gwydir Valley Irrigators Association, June 1999, November 2001 - Environmental Impact of irrigation in the Gwydir Valley.

3.2.07	**Adam Downey** presented at the Cotton CRC, Narrabri on the 27th of April at the Cotton CRC/CRDC Postgraduate Visit to Narrabri, held on the 26th and 27th of April 2001 - Effects of defoliants on Native Trees.
3.2.07	**Adam Downey** presented in Ecosystem Management at the University of New England on the 14th December 2000, for a meeting on the progress of joint Cotton CRC/UNE research projects.
3.2.08	**Dr. Vervoort and Dr. Minasny** were invited for a workshop on Modelling Water Flow in Cracking Clays organised by Agriculture Vic. and NSW Agriculture and sponsored by NPIRD: Melbourne May 16 and 17, 2001.
4.1.01	**James Quinn** - Cotton Trade Show - Industry Development Officer Moree.
4.1.01	**James Quinn** Cotton CRC Industry development Officer - Moree - is the Chairman of the Gwydir Valley Field Days Committee. Field days attracted 80 people & several farms in the area were visited.
4.1.02	**Guy Roth** - Rotary Youth Agriculture Conference, Moree **-** Cotton Production Course.
4.1.02	**Guy Roth** - About 15 schools - Cotton Production Course.
4.1.02	**Guy Roth** - Ag Quip Field Day - Cotton Production Course.
4.1.02	**Guy Roth** - Sydney University, UQ Gatton, and Orange Agricultural College - Cotton Production Course.
4.1.06	**Ms Sabina Kindler** presented the preliminary project findings at the end of her summer studentship to scientists at the Australian Cotton CRC, Narrabri.
4.2.01	**Phil Goyne** - *Qld State Govt Delegation, Hermitage Research Station 31-8-00* - Water Use Efficiency.
4.2.01	**Okello-Okanya, J and Springer, D**. Emerald Ag Grow Show, July 2000 - Water use Efficiency.
4.2.01	**Phil Goyne** - *Farming Systems Cotton Grower Tour, Dalby 6-12-00* - Water Use Efficiency.
4.2.01	**Phil Goyne** - *Integrating our Approaches workshop, Emerald 25-7-00* - Water Use Efficiency.
4.2.01	**Phil Goyne** - *Measure to Manage Workshops: Dalby, Mackenzie River, Emerald, Theodore* - Water Use Efficiency.
4.2.01	**Spragge, A.** Moree Cotton Trade Show, May 2001 - Water Use Efficiency.
4.2.01	**Springer, D**. Biloela Agricultural Show in May 2001 - Water Use Efficiency.
4.2.06	**Ziaul Hoque** - A presentation was given to the Students of the University of Western Sydney on August 24, 2000. Economic analysis of insect resistance management.
4.2.06	**Ziaul Hoque** - A presentation was given in the Cotton Consultants Australia (CCA) Workshop, July 26, 2000, Goondiwindi, Qld - Economic analysis of insect resistance management.
4.2.06	**Ziaul Hoque** - A presentation was given in the National Cotton Extension Workshop, July 20, 2000, Yamba, NSW - Economic analysis of insect resistance management.
4.2.06	**Ziaul Hoque** - A presentation was given to the Students of the Cotton CRC's course on July 25, 2000 - Economic analysis of insect resistance management
4.2.06	**Ziaul Hoque** presented a case study about the project activities, was presented and discussed at the NSW Agricultural Economist workshop, October 10-12, 2000, Wagga Wagga Agriculture Institute, NSW.
4.3.00	**David Larsen** - Mobile TRC to *CottonLOGIC* workshops: Goondiwindi, Pittsworth, Dalby, Theodore, Emerald, St George, Walgett, Bourke, Hillston, Condobolin, Trangie, Warren, Moree, Narrabri, Gunnedah.
4.3.01	**Mike Bange** - *CottonLOGIC* promotion at the Macquarie food and fibre festival
4.3.01	**Mike Bange** - Promotion by the Cotton LOGIC team of *CottonLOGIC* at the 2000 Moree trade show.
4.3.01	**Mike Bange** - The *CottonLOGIC* training workshops occurred in August and September 2000. A total of seventeen workshops were conducted from as far as Murgon in QLD to Hillston in NSW. The new areas covered were Murgon and Condobolin. A total of 250 participants attended the workshops, which were similar figures to the 1999 workshops.
5.1.00	**J Cai** - A presentation was given at a Cotton CRC board meeting in Sydney in October 2000 - Innovative Bleaching Technologies.

5.1.00 **J Cai** - A presentation was given at a Research Meeting at CSIRO TFT on May 16, 2001 - Innovative Bleaching Technologies.

5.3.01 **Chris Dorahy** - CRC Cotton Production Course: "The phosphorus (P) nutrition of cotton": The University of Sydney, 17 May, 2001; The University of New England, 30 March, 2000; ACRI Narrabri, February 13, 1999.

5.3.01 **Dorahy, C.G. Blair, G.J. and Rochester, I.J.** (1999). "The phosphorus nutrition of cotton in alkaline soils in Australia". Texas Tech University, 26 August 1999, Lubbock, Texas, USA.

5.3.01 **Dorahy, C.G., Rochester, I.J. and Blair, G.J.** (2000). "Improving P fertiliser decisions for cotton". *The Cotton Consultants of Australia Annual Meeting*. 15 June 2000, Moree, NSW.

TRADE SHOWS:

4.3.00 **David Larsen** - Australian Cotton Trade Show, Moree CRC display and Technology Resource Centre promotion.

4.3.00 **David Larsen** - 10th Australian Cotton Conference CRC display including Technology Resource Centre display.

4.3.00 **David Larsen** - Field days at various sites: Mobile TRC set up to distribute paper based packages and *CottonLOGIC*

Cotton growers enjoying a hands-on demonstration at the Australian Cotton Trade Show in Moree.

GROWER MAGAZINES & ARTICLES:

2.2.03 **Gregg, P.** (2000) Early warning on punctigera build-up. Video segment on Cotton World, Issue 7, Spring 2000 Cotton Management Pty Ltd, Toowoomba

2.2.05 **Dr Joe Kockman** "DNA Diagnostics for *Fusarium* Wilt of Cotton" brochure prepared and distributed throughout industry groups.

3.1.00 **Hulugalle, N.R.** (2001). Sodicity and soil structural stability in cotton-growing soils. Aust. Cottongrower, 22, In press.

3.1.00 **Hulugalle, N.R., and Weaver, T.** (2000). Leaching in cracking clays. Aust. Cottongrower, 21(3), 60-64.

3.1.00 **Hulugalle, N.R., and Weaver, T.,Finlay, L., and Magann, D.** (2000). Injecting anhydrous ammonia into standing wheat stubble. Aust. Cottongrower, 21(5), 64.

3.1.00 **Weaver, T., Finlay, L., Hulugalle, N., and Magann, D.** (2000). Injecting anhydrous ammonia into standing wheat stubble. Aust. Cottongrower, 21(5), 64.

3.1.02 **McKenzie D, Shaw A, Rochester I, Hulugalle N and Wright P** (2001). Soil and nutritional management for cotton. Agfact P5.3.6 2nd edition. Division of Plant Industries. NSW Agriculture.

3.1.03 **Dirk Rickards, Michael Bange and Steve Milroy** "The 2000/2001 season - weather in review" The Australian CottonGrower 23/5/01

3.1.03 **P. Thongbai** invited to write a chapter 'Waterlogging in Cotton' *in* '*NUTRIpak*: A Practical Guide to Cotton Nutrition', 2001. I. Rochester (ed.). Cotton Research and Development Corporation. (In press).

3.1.03 **P. Thongbai,** 2000. What happens when cotton got wet feet? Article in Cotton Magazine, November 2000. Cotton Grower Services (CGS), Narrabri, NSW.

3.1.03 **P. Thongbai.** 2000. No more wet feet for cotton, p 34 in Farming Ahead: With the Kondinin Group (No. 104: August 2000).

3.1.03 **Richards, D.Q., Bange, M.P., and Milroy, S.P.** (2000). Where did all the sunshine go? – The 1999/2000 season weather in review. 21(3) The Australian Cottongrower pp.24-27.

3.1.07 **Roberts, G.N.** (2001). Integrated cotton weed management. *The Australian Cotton Grower*, **22**(2), 37-39.

3.1.07 **Roberts, G.N.** and Hickman, M. (2000). Herbicide control of unwanted cotton plants. *The Australian Cotton Grower*, **21**(4), 8-10.

3.1.11 **I.O.A Odeh.** 2000. Soil quality assessment in the cotton-growing regions of Eastern Australia. Presented at the meeting organised by Cotton Consultants Australia Inc , Goondiwindi, QLD. July 26-27, 2000.

3.2.00 **A.I. Huckel, M. McRae, and J. Triantafilis** (2000). Mapping soil texture in a leaking storage. The Australian Cotton Grower, Toowoomba Queensland, Sept-Oct. pp. 55-60.

3.2.00 **J. Triantafilis, M.F. Ahmed and I.O.A. Odeh** (2000). Estimating the impact of increasingly saline water use in the lower Namoi valley. The Australian Cotton Grower, Toowoomba Queensland, May-Jun. pp. 58-60.

3.2.06 **J Montgomery** - Cotton Magazine, October 1999. 'Cotton CRC studies irrigation impact in the Gwydir Valley', pp. 9.

3.2.06 **J Montgomery**. The Land, Cotton 99, September 1999. 'Gwydir Valley Irrigation Study', pp. 16.

3.2.07 **Adam Downey** recently had an article published in the 2001 March/April edition of "*The Australian Cottongrower*" magazine. The article, titled, "*Cotton defoliants and native trees*" was jointly edited by my supervisors and myself and was jointly published under all three names. The article was an incorporation of a summary of my 1999 glasshouse experiment on this topic and an overview of the current research project to date.

3.2.07 **Adam Downey** sent a brief press release to several papers in the north-west NSW region about the current research project. Articles were published in "*The Namoi Valley Independent*" (Gunnedah), and "*The Tamworth Times*" (Tamworth) to the best of our knowledge. Articles may also have been published in other papers such as "*The Courier*" (Narrabri).

4.1.02 **Roth, G. W.** (2000) Specialised cotton industry training expands. *The Australian Cotton Grower Year Book*, 106-108.

4.1.02 **Roth, G.W.** (2000) Cotton industry training. *Australian Rural Science Annual*,pp 53-54.

4.2.06 **Ziaul Hoque** "Better profits from Soft chemical options", Economics research in Australian Cotton Research Institute, Cotton Magazine, ACRI issue, October 2000.

4.2.06 **Ziaul Hoque and Bob Farquharson,** "Practising IPM on my Farm will only Cost Money! Or Does It?" review of project findings published in the Upper Namoi Cotton Growers Magazine, July-August 2000**.**

4.2.06 **Ziaul Hoque** "Better profits from 'Soft' chemical options", a report on project outcomes and Ziaul's interview published in the Cotton Magazine, September 2000.

4.2.06 **Ziaul Hoque** "Spray strategy lifts profit" a report on project outcomes and Ziaul's interview published in the Australian Cotton Outlook, September 2000.

4.2.06 **Ziaul Hoque and Bob Farquharson,** "Soft chemical options can be economically profitable in cotton IPM" **by** *Plant Slants*, Monthly Bulleting of the Division of Plant Industry, NSW Agriculture, August 2000.

4.2.06 **Ziaul Hoque, Bob Farquharson, Martin Dillon and Greg Kauter,** "Soft options can reduce costs and increase cotton profits" 'The Australian Cottongrower' July-August, 2000

5.3.01 **Dorahy, C.G.** (2000) What do the Queen, American cotton soils and P have in common? *The Australian Cottongrower* **21** (2): 85-86. Brisbane, Qld: Greenmount Press.

5.3.01 **Dorahy, C.G., Rochester, I.J. and Blair, G.J.** (1999) Phosphorus nutrition of cotton: Unravelling the mystery. *The Australian Cottongrower* **20** (4): 60-62. Brisbane, Qld: Greenmount Press.

MEDIA RELEASES

Guy Roth, Lecturer with UNE's Cotton Production Course, with cameraman from PRIME News in the background at the launch of Cotton Modules, the latest in teaching technology

Jul-00	"Cotton Agronomist Visit Armidale to Study the Environment"
Jul-00	"New ideas in Cotton Pest management"
Jul-00	ACRI Feature in "The Narrabri Courier" "ACRI Overview", "Past Achievements, Future Direction, Contribution to Industry and Local Community", "NSW Agriculture: A Long History of Cotton Research & Development", "CSIRO's Strong Commitment to Cotton Research", "Immense Benefits to Industry from Cotton CRC", "ACRI's Insect Busters", "Breeding a Better Cotton Industry" "A Tractors Drivers View of *Fusarium* Wilt" Single Page Brochure", "Pathologists Win Some Battles but not the War", "Farming Systems "Packages" are the Answer", "Which Rotation Crop?", "Cotton Yield Recovery", "Winning rhw Weed War with Research", "Water Use Efficiency", "What Happens when Cotton Gets Whet Feet?", "Technology Transfer the key to Cotton's Future", "Better Profits from 'Soft' Chemical Option" and "Its Not Just Cotton at ACRI".
Aug-00	"Cotton CRC Sweeps the Awards at the ACGRA Cotton Conference"
Aug-00	"Fight Against *Fusarium* Wilt Increases"
Sep-00	"Cottoning On"
Sep-00	"New Chairman for the Cotton CRC"
Sep-00	"Weeds"
Oct-00	"Fast *Fusarium* Identification Kit Developed"
Nov-00	"Cotton Production Course Wins National Award"
Nov-00	"*CottonLOGIC* - Latest release delivers"
Dec-00	"Cotton Insect Threat Reviewed"
Jan-01	"Cotton Salinity Threats Identified"
Feb-01	"Guidelines for growers on Cotton Nutrient Problems"
Feb-01	"Understanding the salinity threat in the irrigated cotton growing areas of Australia" and "Ecosystem Services in the Gwydir Valley"
Apr-01	"New Cotton Graduates"
May-01	"Cotton Course Expands to Gatton"
June-01	"Cotton Modules" - the latest in teaching technology

AWARDS

3.1.02 **Dr Ian Rochester** was awarded the ACGRA Cotton Researcher of the Year 2000 (17/8/00).

4.1.02 **Guy Roth** Business and Higher Education Round Table 2000 Award for Outstanding Achievement in Collaboration in Education/Training. Cotton Production Course.

VISITORS

- Greenhouse Office
- The University of Sydney
- The University of Queensland Technology
- Namoi Water Users Association
- Lower Namoi Cotton Growers Association
- The Irrigation Association of Australia
- A group of University of Sydney Students on a field trip with Associate Prof. Alex McBratney
- A group of Extension Officers from the University of Georgia
- Queensland Cotton and St George cotton growers tour
- National Cotton Producers Organisation – South Africa tour
- Ecomcotton Australia Pty Ltd and Chinese Cotton delegation tour.
- Eucalypt Forestry industry tour.
- The University of Sydney, Department of Crop Science final year field trip.
- Brazilian Cotton Growers Tour
- Dr Bill Weir from the University of California USA tour plus four US cotton/tomato growers.
- GRDC National Panel visit.
- University of Western Sydney, Hawkesbury and two Indian Agricultural Officers – on tour.
- A group of cotton growers from California and Arizona on tour.
- The Chinese ACVSMC Delegation tour (All China Federation of Supply and Marketing Cooperatives training Centre).

PUBLIC RELATIONS

- **Dr Gary Fitt**, presentation to Dalby/Wambo/Chinchilla/Jonderyan Council Shires September 13th 2000 - Genetically Modified Crops.
- **Dr Gary Fitt**, presentation to Dubbo Shire Council September 7th 2000 - Genetically Modified Crops.
- **Dr Gary Fitt**, presentation to Emerald Shire Council January 24th 2001 - Genetically Modified Crops.
- **Dr Gary Fitt**, presentation to Goondiwindi/Wagamba Shire Councils September 14th 2000 - Genetically Modified Crops.
- **Dr Gary Fitt**, presentation to Gunnedah Shire Council August 9th 2000 - Genetically Modified Crops.
- **Dr Gary Fitt**, presentation to Hillston Shire Council March 2001 - Genetically Modified Crops.
- **Dr Gary Fitt**, presentation to Narrabri Shire Council July 18th 2001 - Genetically Modified Crops.
- **Dr Gary Fitt**, presentation to Warren Shire Council December 7th 2000 - Genetically Modified Crops.

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

AUDITOR'S REPORT TOTHE COOPERATIVE RESEARCH CENTRES PROGRAM, DEPARTMENT OF INDUSTRY, SCIENCE AND RESOURCES REPRESENTING THE COMMONWEALTH IN RESPECT OF THE AUSTRALIAN COTTON COOPERATIVE RESEARCH CENTRE FINANCIAL INFORMATION FOR THE YEAR ENDED 30 JUNE 2001

Scope

We have audited the financial information of the Australian Cotton Cooperative 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 2001. The parties of the Cooperative Research Centre are responsible for the preparation and presentation of the 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 Cooperative Research Centre.

The financial information has been prepared for the parties to the Australian Cotton Cooperative Research Centre for the purposes of fulfilling their annual reporting obligations under clause 14(1) (f) of the Commonwealth Agreement and for distribution to the Cooperative Research Centres Program, Department of Industry, Science and Resources, representing the Commonwealth of Australia. We disclaim any assumption of the 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 of other disclosures in the financial information, and the evaluation of accounting policies and significant accounting estimates. These procedures have been undertaken to form an opinion whether, in all material respects, the financial information is presented fairly in accordance with 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 and the application of the funding of the Australian Cotton Cooperative Research Centre and the application of which is consistent with our understanding of its financial activities during the year and its financial position.

NARRABRI
1/155 Maitland Street, 2390
P.O. Box 117,
Telephone (02) 6792 2195
Facsimile (02) 6792 3670
Email: mail@macarriganco.com.au

WEE WAA
3/71 Rose Street, 2388
P.O. Box 40,
Telephone (02) 6795 4855
Facsimile (02) 6795 4107
Email: mail@macarriganco.com.au

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 equaled or exceeded the amount of grant paid during the year (not including advances) [Clause 5].

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 irregularties. [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 $430,000 over the original budgeted figure for the respective heads of expenditure.

   - other expenditure which were $199,000 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 Ventre 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 Ventre 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)].

25th September 2001

Signature: .....

Current Research Grants held by the Chief Executive Officer and key Cotton CRC researchers

Researcher	Title of grant	Scheme	Grant period	Total $'000s
Dr Geoff Naylor	Development, Manufacture and Commissioning of an Instrument for Computer Image Analysis of Dyed Cotton Fabric Visual Quality.	CRDC	2000/01	22
Dr Geoff Naylor	Measuring Cotton Fineness and Maturity using the Sirolan-Laserscam.	CRDC	1999/01	170
Dr Gary Fitt	Ecological aspects of Helicoverpa populations relating to the successful deployment of Bt transgenic cottons.	CRDC	1997/00	300
Dr Gary Fitt	Insect pest resistance and the role of induced responses to damage in Australian cottons.	CRDC	1999/02	331
Dr Michael Bange and Dr Stephen Milroy	The impact of temperature extremes on cotton performance.	CRDC	2001/04	315
Dr Lewis Wilson	Management of early season damage and secondary pests in cotton.	CRDC	1999/02	572
Dirk Richards and Dr Michael Bange	Application of crop simulation in the Australian Cotton Industry.	CRDC	2001/04	355
Dr Michael Bange and Dr Stephen Milroy	Training in crop physiology – Functional responses of cotton to environment mediated via internal nitrogen dynamics.	CRDC	2001/04	87
Dr Michael Bange and Sandra Deutscher	Continued development and field evaluation of microcomputer cotton management packages.	CRDC	2000/03	396
Dr Michael Bange	Enhancing access to climate and weather data.	CRDC	2000/03	145
Dr Michael Bange and Darren Linsley	Enhancing development, support and evaluation of computerised decision support.	CRDC	1999/02	259
Professor Alex McBratney	Development of "Nutrilogic" for precision agriculture – a decision support system for agrotechnology transfer in the cotton industry. Postgraduate Research Scholarship for Craig Stewart.	CRDC	1998/01	87
Professor Alex McBratney	Development of Nutrilogic for precision agriculture – a decision support system for agrotechnology transfer in the cotton industry.	CRDC	1998/01	52
Professor Alex McBratney	Soil Physics Equipment.	CRDC	2001/02	44
Professor Alex McBratney	Variable-rate application of nitrogen: the determination of an empirical methodology for implementation.	Australian Research Council	2001/03	36
Professor Alex McBratney	Variable-rate application of nitrogen: the determination of an empirical methodology for implementation - Equipment Purchases.	Australian Research Council – Development Links Program	2001/03	240
Professor Alex McBratney	Variable-rate application of nitrogen: the determination of an empirical methodology for implementation – Equipment for project.	Incitec LTD	2001/03	14
Professor Alex McBratney	Precision agriculture (PA) farming systems research group – Northern region.	GRDC	1999/02	172
Dr David Murray	Heliothis management for IPM in grain crops.	GRDC	1996/01	795
Dr David Murray	Regional management of heliothis on the Darling Downs.	GRDC	1998/01	192
Dr David Murray	Regional management of heliothis on the Darling Downs.	CRDC	1998/01	192
Dr David Murray	Pest status and management of shield bugs in cotton.	CRDC	2000/01	95
Dr David Murray	Thresholds for green mirids in cotton.	CRDC	1998/01	296
Dr David Murray	IPM in dryland cotton on the Darling Downs.	CRDC	1999/02	379
Assoc. Professor Peter Gregg	Management of resistance in Bemisia tabaci.	CRDC	1998/01	81
Assoc. Professor Peter Gregg	Attractant and kill technology for *Helicoverpa armigera*.	CRDC	1999/02	87
Assoc. Professor Peter Gregg	Ecology of beneficial insects in cotton systems.	CRDC	2000	7
Assoc. Professor Peter Gregg	Impact of GM crops on pesticide use.	Academy of Technology, Science and Engineering	2001	7
Assoc. Professor Peter Gregg	Environmental assessment of GM canola.	Environment Australia	2001	45
Geoff Strickland	Defining IPM for NW Australia.	CRDC	1999/02	268
Geoff Strickland	Centres of Excellence – Research infrastructure support.	Department of Commerce & Trade	2000/03	275
Geoff Strickland	Biological control of Paterson's curse.	AWRAP & MLA	1998/02	227

Performance indicators

Nature of Indicator	Performance Indicator	Year 2 Performance 2000-2001
Objectives of the Centre		
Outcome	Economic benefit to Centre	■ CRC priorities closely aligned to sustainability needs of the cotton industry. ■ Increasing interaction with wider community with environmental research addressing issues of national importance. ■ Substantial funding secured from CRDC ($1.2 million in 2000/2001). ■ Enhanced sustainability of industry will maintain economic benefits to rural communities and Australian exports. ■ Commercialisation of one potential product in train with IP protection established. Centre IP fully assessed. ■ Research in northern Australia established in four regions. Developing links to government and community groups to facilitate future industry development contingent on research outcomes. ■ Significant move to establish public good environmental management research program.
Input	Total resources	■ Total centre resources exceed $16 million (target $12.7 million for Year Two). ■ Total leverage to date > 7.3 vs. Commonwealth cash (target > 6.0). ■ Total cash resources year two - $5.03 million (target $3.55 million for Year Two). ■ Cash 31% of total resources to date (target 24% for life of the Centre).
Process	Program/ project management	■ Board, Management Committee and Northern Committee established. ■ Annual plan and budget agreed. ■ Advisory committee established – comprising external scientific, industry and community representatives. ■ Process for formal Annual Review of all projects established with second year review July 2001. ■ Representative discipline groups established and provide feedback on progress and priorities.
Outputs	Centre reports and publications transferring outcomes and technology to industry	■ IPM Guidelines for Australian Cotton widely distributed and undergoing revision. ■ Five documents were produced by the Technology Resource Centre in response to industry needs. These were 'A Tractor Drivers Guide to *Fusarium*', 'Black Root Rot Update', March 2000 (Cotton CRC Information Sheet), 'Planting Cotton into Wheat Stubble' (Cotton CRC Information Sheet), 'IRMS Strategy Cards', 'What to do when you have *Fusarium*' (Cotton CRC Information Sheet). ■ Distribution of 872 *EntoPAK*'s, enhanced with new material, and 532 copies of SoilPAK to growers. ■ A major upgrade of *CottonLOGIC* (Version 4.0) was completed in late December 2000, with over 1,112 registered users across the industry at the end of 2001. Major new features were gross margin reports, cost/ha report, data exporting facilities, data recovery utilities and enhancements to spray ordering forms. ■ Northern Australia Scoping document printed and ready for release in the second quarter of 2001-2002. ■ Cotton CRC website upgraded and averaging 540 visits per day. ■ Cotton CRC eNews alerts users to important new web content and CRC developments distributed to over 800 addresses. ■ Over 2730 clients on the industry database. ■ A simple but effective interface for the *OZCOT* crop simulation model has been developed. Two-day workshops to instruct Cotton CRC extension personel in the responsible use of *OSCOT* and *CottonLOGIC* have been held.

Nature of Indicator	Performance Indicator	Year 2 Performance 2000-2001
	Short courses	■ Development of IPM short course complete. First pilot courses with growers held in the summer of 2001. Over 200 growers are expected to have completed the course by the end of 2002. ■ Seventeen training workshops in the use of *CottonLOGIC* were held with groups from Murgon in CQ to Hillston in Southern NSW. A total of 250 participants attended the workshops.

Quality and relevance of the research program

Outcome	Scientific status & user satisfaction	■ Industry involved in all discipline groups where identification of priorities and evaluation of research progress are addressed. ■ Advisory committee provides independent scientific assessment of progress. ■ Links to other research organizations help to maintain scientific status. ■ Seven industry and other awards, including Chris Dorahy awarded a travelling scholarship from the Queens Trust for Young Australians and Ian Rochester awarded the ACGRA 'Cotton researcher of the Year'.
Input	Research program resources	■ $30.85 million cash and in-kind resources on research program to date (target $61.6 million over the life of the Centre). ■ Distribution of resources across programs in line with business plan.
Process	Involvement with research users and industry	■ Eleven discipline groups and coordinators established to identify priorities and assess progress. Australian Cotton Growers Research Association and Cotton Consultants Association represented on each group. ■ CRC Advisory Committee established with representatives of industry (2), independent scientists (3), extension specialist (1) and community groups (3). Advisory Committee assists Management Committee in annual review process. ■ Management Committee completes project selection process with input from discipline groups. ■ Northern Committee established to represent all commercial interests and research users in northern Australia to advise on research needs. ■ CRC fully represented on Board of the Australian Cotton Industry Council. ■ CRC represented in Cotton Consultants Australia Inc. and liaises closely with Cotton R&D Corporation Board. ■ Steering Committees established for projects in Water Use Efficiency (Qld) and Environmental Impacts of Irrigation (Gwydir), Ecosystem Services (Gwydir), Bioremediation (Namoi) and Salinity Risk Assessment projects (Various NSW Regions). ■ New working groups established to research specific issues – Northern Murray Darling Basin Water Balance Group, Greenhouse Working Group. ■ Regular liaison with Grains Research & Development Corporation, Land & Water Australia, Murray-Darling Basin Commission, Namoi Irrigators Association, CRC for Freshwater Ecology, National Program for Irrigation R & D, Australian Greenhouse Office, Carbon Accounting CRC, Sugar CRC, Rice CRC, Weeds CRC, Tropical Plant Protection CRC, Cotton Australia, Irrigation Association of Australia, Namoi Cotton Growers Association and Queensland Department of Natural Resources and Mines.
Outputs	External publications	■ 54 journal papers and book chapters, 40 conference and other publications. ■ More than 151 presentations at Conferences, Workshops, grower meetings. ■ 27 grower magazine articles and 34 press interviews.

Nature of Indicator	Performance Indicator	Year 2 Performance 2000-2001
Strategy for utilisation and application of research outputs		
Outcome	Improve end user adoption	■ Communication plan in place. ■ Commitment to effective mixture of written, face-to-face and electronic information delivery. ■ Maintenance of long-term farming systems sites researching sustainable farming practices. ■ Establishment of additional demonstration sites for specific farming system issues. ■ Twenty demonstration sites established for Water Use Efficiency studies in Queensland.
Input	User core participant resources	■ $2.24 million in-kind devoted to technology transfer and communications in Year Two. ■ Technology Resource Centre as key physical resource for packaging and distribution of printed and electronic information. ■ $2,710 million on technology transfer.
Process	Communication and implementation of centre research outcomes and technology	■ Eight Industry Development officers and six Water Use Efficiency Extension officers located strategically throughout the industry as well as five farming System Extension officers in NSW Ag and QDPI who contribute part of their time to cotton extension. Two Spray Application Extension officers, one IPM training coordinator, one Trainee Industry Development Officer and one National Extension Coordinator. ■ Water Use Efficiency officers established in six regions throughout Queensland to support adoption of Best Management Practices for irrigation. Results from an irrigator survey reveal that over 50% (in some regions up to 100%) of grower irrigators are involved with Best Management Practices and attended Water Use Efficiency workshops. ■ Research program outcomes packaged for industry use. ■ Industry BMP Guidelines reflect latest research outcomes. Centre staff involved in planning for additional BMP modules on irrigation and disease management. ■ Key researchers in all projects involved in industry field days and many participate in research at focal farming systems locations.
Outputs	Commercialisation and IP management	■ Business plan completed and IP protection in place for one project. ■ Discussions with potential commercial partners initiated. ■ Assessment made of other Centre IP.
	Technology transfer and adoption	■ Eighteen Industry publications, including IPM Guidelines, *EntoPAK*, *NutriPAK*, *NutriLOGIC* and numerous disease management guides. ■ Distribution of 178 information packs. ■ Release of new version of *CottonLOGIC* in December 2000. ■ Award winning Cotton CRC website upgraded. ■ Seventeen *CottonLOGIC* workshops across all regions, including northern Australia. ■ Information stand at Australian Cotton Trade Show, Moree and information stand at 'Science in the City' Sydney. ■ Thirteen fields days in established regions, plus Research Update and Field Day in the Ord River Irrigation Area, WA. ■ Cotton Research Open Day for general public at Australian Cotton Research Institute, Narrabri
	PR/ Press Releases·	■ Thirty six press releases ■ Cotton CRC display produced and used at Richmond Community Forum, Darwin Show, Australian Cotton Conference, Brisbane Exhibition and Science in the City (Sydney) to raise awareness about CRC activities.

Nature of Indicator	Performance Indicator	Year 2 Performance 2000-2001
Collaborative arrangements		
Outcome	Cooperation in research within Australia and overseas and more efficient use of resources	■ Informal linkages to 10 cotton research institutions in the USA, China and Japan. ■ Collaborative projects (4) involving researchers from USA, China and Japan. ■ Joint projects established or planned with four other CRCs – Weeds, TPP, Carbon Accounting, and Sugar. ■ Research discussions with CRCs for Freshwater Ecology and Catchment Hydrology.
Input	Research Providers FTE In Kind·	■ Year 2 – Researchers 37.51 full-time equivalents in kind increased from 32.19 last financial year. (target 47.7 over the life of the Centre).
Process	Collaboration Between Researchers	■ Sixty nine percent of projects involve two or more participants. ■ Use of shared facilities. ■ Annual research review and discipline groups provide forums to develop collaborative links. ■ All students with at least one non-academic supervisor. ■ Collaborative linkages established with external research associations. ■ Summer scholarships involve undergraduate students from four universities outside the CRC participants.
	Collaboration between researchers and research users	■ Industry Advisory Committee meetings annually. ■ Northern Committee met once in Year 2 – confirmed research directions. ■ Eleven discipline groups maintained – most met at least once in Year 2 with written reports produced and all groups maintain regular e-mail discussion. ■ Annual research review completed in July.
	International Collaboration	■ Five international exchanges in Year 2. Three researchers visited the US, one went to Brazil and one US researcher visited Australia. Three centre researchers participated in international conferences. ■ Student presentations at conferences.
Outputs	Collaborating authors on publications	■ Collaborating authors on 38 % of centre publications.

Nature of Indicator	Performance Indicator	Year 2 Performance 2000-2001
Education and training		
Outcome	Cotton production courses	■ Twenty people graduated from the Cotton Production Course (Certificate and Diploma) in April 2001 – 112 have now graduated, 46% over the last two years. Forty five students were admitted in 2001. ■ The *Cotton Modules* CD ROM is now available to students. ■ Twenty one undergraduates completed the Applied Cotton Production unit at UNE. The undergraduate program is now delivered to four other universities – twenty one students at University of Queensland, fifteen students at University of Sydney, three students at University of Western Sydney and five students at Orange Agricultural College. ■ Cotton Consultants Australia Inc. adopts Cotton Production Course as requirement for accreditation as Certified Practicing Cotton Consultant.
Input	Education and Training program	■ $0.65 million cash and in-kind resources committed to education strategies in Year Two (target $3.3 million over the life of the centre). ■ Thirty in-kind scientists have input to course delivery.
Process	Industry training	■ Year 2 – 17 training workshops completed. ■ IPM short course developed in consultation with industry.
Outputs	Students, scholarships, lecturer·	■ Three Postgraduates completed in Year 2. ■ Thirty students graduated from Cotton Production Certificate Course. ■ Four undergraduate scholarships commenced. ■ Four summer scholarships and two Honours Scholarships supported. ■ CRC lecturer position maintained and at least 30 scientists involved in presentation of course.
Management structure and arrangements		
Outcome	Continuity of long term research effort	■ Most parties maintain commitment to centre.
Input	Total cash and in-kind resources in general administration program	■ $0.515 million cash and in-kind resources for Year Two (target $2.2 million over the life of the centre). These figures include the CRC communication strategy and accommodate current staff salary levels.
Process	Governing Board	■ Board established with Chair and two independent directors. Independent directors drawn from processing and environment areas. ■ Majority of directors independent of research providers (7/12). ■ Timetable of quarterly board meetings established.
	Project management skills	■ Board approval for program of leadership training for program leaders and future leaders in the centre.
Outputs	Financial management and reporting	■ Budget reports and cash flow projections provided to Board and Management Committee quarterly. ■ Financial data maintained on MYOB accounting.
	Monthly, quarterly and Annual Report on time	■ Financial reports submitted on time to the Board. ■ Annual report submitted in second quarter. ■ Quarterly cash flow statements submitted.

RESEARCH STAFF RESOURCES ATTACHMENT A

IN-KIND CONTRIBUTION BY ORGANISATION (PERSON YEARS)2000/2001

CSIRO	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Akhurst, Ray (Dr)	R	75		75			75				
Baker, Geoff (Dr)	R	80		40	40		80				
Bange, Michael (Dr)	R	40	30				30	5		5	
Brown, Tony (Dr)	R	10	10				10				
Brubaker, Curt (Dr)	R	30		30			30				
Carberry, Peter (Dr)	R	30	10		10		20			10	
Christian, Peter (Dr)	R	25		25			25				
Collof, Matt (Dr)	R	30			30		30				
Constable, Greg (Dr)	R	20	5		10		15	5			
Cookson, Peter (Dr)	R	15				10	10	5			
Dalgliesh, Neil (Dr)	R	30			20		20			10	
Daly, Joanne (Dr)	R	25		25			25				
Deutscher, Sandra	T	40					0			40	
Dillon, Martin	R	100	45		50		95	5			
Duggen, Brian (Dr)	R	100	100				100				
Eastick, Rowena (Dr)	R	100	100				100				
Evans, David (Dr)	R	15				15	15				
Hochman, Zvi (Dr)	R	30	10		10		20			10	
Johnston, Scott	T	40					0			40	
King, David (Dr)	R	50				50	50				
Lei, Tom (Dr)	R	40			40		40				
Linsley, Darren	T	40					0			40	
Mahon, Rod (Dr)	R	80			80		80				
Milroy, Steve (Dr)	R	40			40		40				
Oakeshott, John (Dr)	R	30		30			30				
Pfeiffer, Tony	T	40					0			40	
Redall, Amelia	R	40			40		40				
Reid, Peter	R	20			20		20				
Richards, Andy (Dr)	R	50			45		45	5			
Richards, Dirk	R	20			20		20				
Robert, Merv (Dr)	R	10			10		10				
Singh, Dhananjay (Dr)	R	100	100				100				
Stiller, Warwick	T	20			20		20				
Tennakoon, Sunil (Dr)	R	40	20		20		40				
Thongbai, Pongmanee (Dr)	R	40			40		40				
Whish, Jeremy (Dr)	R	20			20		20				
Whitehouse, Mary (Dr)	R	100			100		100				
Whiteside, Stewart	R	40					0			40	
Wilson, Lewis (Dr)	R	40			35		35	5			
		16.95	**4.30**	**2.25**	**7.00**	**0.75**	**14.30**	**0.30**	**0.00**	**2.35**	**0.00**

NSWA	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Blumenthal, M Dr	R	10			10		10				
Charles, Graham	R	65			60		60	5			
Cooper, Jack	R	40			40		40				
Farquharson, Bob	R	25			25		25				
Friend, John	R	40			40		40				
Gibb, Dallas	T	75					0	10		65	
Greenslade, Raelene	T	20					0			20	
Gunning, Robin	R	40			40		40				
Heimoana, Viliama	T	100			90		90	10			
Hickman, Mark	T	100					0			100	
Hulugalle, Nilantha (Dr)	R	65			65		65				
Jenkins, Leigh	T	60					0			60	
Khan, Moazzem	R	50			50		50				
Mensah, Robert (Dr)	R	40		35			35	5			
Nehl, David (Dr)	R	65	5	20	30		55	5		5	
Parker, Myles	T	20					0			20	

Putcha, Subbu (Dr)	R	40		40			40				
Rourke, Kirrily	T	100					0			100	
Shaw, Gus	T	70					0			70	
Smith, Peter	T	10					0			10	
Swann, Barry	T	50					0			50	
Tonkin, Cameron	T	20			5		5			15	
Vancov, Tony	R	20			20		20				
Watson, Chris	T	65					0			65	
		11.90	**0.05**	**0.95**	**4.75**	**0.00**	**5.75**	**0.35**	**0.00**	**5.80**	**0.00**

DPIQ

	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Franzmann, Bernie	R	25	10		15		25				
Ferguson, Julie	R	25			25		25				
Gordon, Ian (Dr)	R	20	10		10		20				
Grundy, Paul (Dr)	R	50		50			50				
Harris, Graham	T	20					0			20	
Hauxwell, Carrie (Dr)	R	50		50			50				
Hughes, Peter	T	60					0			60	
Kelly, David	T	100					0			100	
Kerlin, Sarah	T	100					0			100	
Kochman, Joe (Dr)	R	40		20	20		40				
Lea, David	R	100			100		100				
McIntyre, Geoff	T	100					0			100	
Miles, Melina (Dr)	R	50			50		50				
Moore, Chris (Dr)	R	10		10			10				
Moore, Natalie (Dr)	R	50			50		50				
Moss, James	R	20	10		10		20				
Murray, David (Dr)	R	30			30		30				
Raymond, Muscha	T	100					0			100	
Salmond, Greg	T	100					0			100	
Scholz, Brad	R	10			10		10				
Sequeira, Richard (Dr)	R	10	5		5		10				
Silburn, Mark	R	20			20		20				
Simpson, Gordon	R	100			100		100				
Waters, David	R	20			20		20				
White, Simon	T	100					0			100	
		13.10	**0.35**	**1.30**	**4.65**	**0.00**	**6.30**	**0.00**	**0.00**	**6.80**	**0.00**

UNE

	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Backhouse, David (Dr)	R	20			20		20				
Blair, Graeme (A/Prof)	R	30			25		25	5			
Daniel, Heiko (Dr)	E	10			10		10				
Faulkner, Richard (A/Prof)	R	20			15		15	5			
Gregg, Peter (A/Prof)	R	50		30	10		40	10			
Jessop, Robin (A/Prof)	E	20					0	20			
Johnson, Stephen	R	100			100		100				
Reid, Nick (A/Prof)	R	30			30		30				
Rollings, Nick (Dr)	R	5		5			5				
Sindel, Brian (Dr)	R	15			15		15				
		3.00	**0.00**	**0.35**	**2.25**	**0.00**	**2.60**	**0.40**	**0.00**	**0.00**	**0.00**

USYD

	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Caldwell, Robert (Dr)	R	20		15			15	5			
Campbell, Lindsay (Dr)	R	10			10		10				
Cattle, Stephen (Dr)	R	10			10		10				
Copeland, Les (Dr)	R	10			10		10				
Godden, David (Dr)	R	10			10		10				
Kennedy, Ivan (Dr)	R	25			20		20	5			
Lees, Edith (Dr)	E	20			10		10	10			

Lyon, Bruce (Dr)	R	20		15			15	5			
McBratney, Alex (Prof)	R	30			25		25	5			
Singh, Balwant (Dr)	R	10			10		10				
		1.65	**0.00**	**0.30**	**1.05**	**0.00**	**1.35**	**0.30**	**0.00**	**0.00**	**0.00**

CRDC	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Dugdale, Helen	T	20					0			20	
Holloway, Rachel	T	10					0			10	
Lester, Tim	T	10					0		10		
Pyke, Bruce	T	30					0			30	
Schulze, Ralph	T	15					0			15	
		0.85	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.10**	**0.75**	**0.00**

CSD	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Allen, Stephen (Dr)	R	50		20	20		40	5		5	
Eveleigh, Robert	T	15					0			15	
Kauter, Greg	T	15					0			15	
Kay, Adam	T	15					0			15	
Marshall, John	T	15					0			15	
		1.10	**0.00**	**0.20**	**0.20**	**0.00**	**0.40**	**0.05**	**0.00**	**0.65**	**0.00**

Ag WA	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Annells, Amanda (Dr)	R	100	100				100				
Moulden, John	R	60	60				60				
Strickland, Geoff	R	70	65				65	5			
		2.30	**2.25**	**0.00**	**0.00**	**0.00**	**2.25**	**0.05**	**0.00**	**0.00**	**0.00**

Queensland Cotton	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Campbell, Ken	R	30	30				30				
Wilson, Barry	R	30	30				30				
		0.60	**0.60**	**0.00**	**0.00**	**0.00**	**0.60**	**0.00**	**0.00**	**0.00**	**0.00**

NTDPIF	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Bellgard, Stan (Dr)	R	20	20				20				
Bennett, Malcolm	R	20	20				20				
Ham, Christopher	R	10	10				10				
Martin, Colin (Dr)	R	75	75				75				
Schultz, Graham	R	50	50				50				
		1.75	**1.75**	**0.00**	**0.00**	**0.00**	**1.75**	**0.00**	**0.00**	**0.00**	**0.00**

WAI	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
McLeod, Ivan	R	30	30				30				
		0.30	**0.30**	**0.00**	**0.00**	**0.00**	**0.30**	**0.00**	**0.00**	**0.00**	**0.00**

TOTAL	**TOTAL 99/00**	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
		53.50	**9.60**	**5.35**	**19.90**	**0.75**	**35.60**	**1.45**	**0.00**	**16.35**	**0.00**

COTTON CRC AND CASH FUNDED RESEARCH STAFF BY ORGANISATION (Person Years)

ATTACHMENT B

CSIRO	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Cai, Jackie (Dr)	R	100				100	100				
Fitt, Gary (Dr)	A	100					0		20	10	70
Hardwick, Scott (Dr)	R	50			50		50				
Mansfield, Sarah (Dr)	R	50			50		50				
Naylor, Geoff (Dr)	R	10				10	10				
O'Brien,Maxine	A	75					0				75
Orman, Kym	A	16					0				16
Press, Lexie (Dr)	R	100		100			100				
Roberts, Grant	R	100			100		100				
Rochester, Ian (Dr)	R	100			100		100				
Rungis, Dainis	R	100		100			100				
Schick, Nicky	A	100					0		20	10	70
Whiteside, Stewart	R	100					0			100	
Yeates, Stehen	R	100	100				100				
		11.01	1.00	2.00	3.00	1.10	7.10	0.00	0.40	1.20	2.31

NSWA	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Hoque, Ziaul	T	100								100	
Larsen, David	T	100							10	90	
Spora, Annie	T	100								100	
Taylor, Ian (Dr)	R	100			100		100				
Quinn, James	T	100								100	
		5.00	0.00	0.00	1.00	0.00	1.00	0.00	0.10	3.90	0.00

DPIQ	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Cameron, Sandy	T	100					0			100	
Christiansen, Ingrid	T	40					0			40	
Dalton, William	T	40					0			40	
Goyne, Phil (Dr)	T	100			100		100				
Hare, Janelle	T	100					0			100	
Hood, Sara	T	100					0			100	
Okell-Okany, John	T	100					0			100	
Spragge, Andres	T	100					0			100	
Springer, Darren	T	100					0			100	
		7.80	0.00	0.00	1.00	0.00	1.00	0.00	0.00	6.80	0.00

UNE	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Del Soccorro, Alice (Dr)	R	90		90			90				
Dorahy, Chris	R	100			100		100				
Downey, Adam	R	100			100		100				
Kvedaras, Olivia	R	100	100				100				
Montgomery, Janelle	R	100			100		100				
Richard Tennant	R	25					0	25			
Roth, Guy	E	80					0	80			
Silberbauer, Letitia (Dr)	R	100			100		100				
		6.95	1.00	0.90	4.00	0.00	5.90	1.05	0.00	0.00	0.00

USYD	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Minasny, Budiman (Dr)	R	75			75		75				
Odeh, Inakwu (Dr)	R	100			100		100				
Sanchez-Bayo, Francisco (Dr)	R	100			100		100				
Triantafilis, John (Dr)	R	100			100		100				
Vervoort, Willem (Dr)	R	100			100		100				
Yan, Florian	R	50			50		50				
		5.25	0.00	0.00	5.25	0.00	5.25	0.00	0.00	0.00	0.00

UQ, UWS and NTDPIF	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
Gulino, Lisa	R	100		100			100				
Malone, Katherine	R	50			50		50				
Ward, Andrew (Dr)	R	50	50				50				
Kindler, Sabina	R	25					0	25			
		2.25	0.50	1.00	0.50	0.00	2.00	0.25	0.00	0.00	0.00

TOTAL	Main Activity	Total % of Time	% Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
			SubProgram				Total on Research				
			1	2	3	5					
		38.26	2.50	3.90	14.75	1.10	22.25	1.30	0.50	11.90	2.31

SUMMARY OF CONTRIBUTIONS IN PERSON YEARS

ATTACHMENT B

	Total Equivalent Person Year	Person Years Spent on Research Program					% Spent on Education Program	% Spent on External Comm.	% Spent on Technology Transfer	% Spent on CRC Admin.
		Subprogram				Total on Research				
		1	2	3	5					
TOTAL CONTRIBUTED	53.50	9.60	5.35	19.90	0.75	35.60	1.45	0.00	16.35	0.00
TOTAL FUNDED BY CRC	38.26	2.50	3.90	14.75	1.10	22.25	1.30	0.50	11.90	2.31
GRAND TOTAL	91.76	12.10	9.25	34.65	1.85	57.85	2.75	0.50	28.25	2.31
Proportion of total professional staff resources in each activity	**100%**	**13.2%**	**10.1%**	**37.8%**	**2.0%**	**63.0%**	**3.0%**	**0.5%**	**30.8%**	**2.5%**

SUPPORT STAFF

ATTACHMENT B

Contributed	
Organisation	**No. Staff (person years)**
Agriculture WA	2.20
Cotton Research and Development Corporation	0.00
Cotton Seed Distributors	0.45
CSIRO	9.30
Dept. Primary Industries, Qld	5.40
NSW Agriculture	6.60
NTDPIF	2.30
Queensland Cotton	0.00
University of New England	0.45
University of Sydney	0.00
WAI	0.20
TOTAL	26.90

CRC Funded (by employing organisation)	
Organisation	**No. Staff (person years)**
Agriculture WA	0.00
Cotton Research and Development Corporation	0.00
Cotton Seed Distributors	0.00
CSIRO	7.85
Dept. Primary Industries, Qld	2.00
NSW Agriculture	3.25
NTDPIF	0.00
Queensland Cotton	0.00
University of New England	0.50
University of Sydney	3.00
WAI	0.00
TOTAL	16.60

IN-KIND CONTRIBUTIONS FROM PARTICIPANTS (DOLLARS IN '000's) TABLE 1

ATTACHMENT C

PARTICIPANT	EXPENDITURE 2000/01 Actual	EXPENDITURE 2000/01 Agr'mt	EXPENDITURE 1999/00 Actual	EXPENDITURE 1999/00 Agr'mt	EXPENDITURE CUMULATIVE TOTAL TO DATE Actual	EXPENDITURE CUMULATIVE TOTAL TO DATE Agr'mt	PROJECTED EXPENDITURE 2000/01 Agr'mt	2001/02 Agr'mt	2002/03 Agr'mt	2003/04 Agr'mt	2004/05 Agr'mt	2005/06 Agr'mt	GRAND TOTAL Total 7 years	Agr'mt 7 years	Diff 7 years
CSIRO															
Salaries	1922	1271	1367	1239	3289	2510	1271	1250	1234	1234	1234	1234	8824	8696	128
Capital	0	0	0		0	0							0	0	0
Other	1737	1157	1162	1129	2899	2286	1157	1140	1120	1120	1120	1120	7939	7906	33
Total	3659	2428	2529	2368	6188	4796	2428	2390	2354	2354	2354	2354	16763	16602	161
NSW Agriculture															
Salaries	1108	1029	1086	1029	2194	2058	1029	1029	1029	1029	1029	1029	7260	7203	57
Capital	0	0	0		0	0							0	0	0
Other	967	1029	967	1029	1934	2058	1029	1029	1029	1029	1029	1029	7141	7203	-62
Total	2075	2058	2052	2058	4127	4116	2058	2058	2058	2058	2058	2058	14400	14406	-6
Qld Dept Primary Industries															
Salaries	1128	945	1195	945	2323	1890	945	945	945	945	945	945	6865	6615	250
Capital	0	0	0		0	0							0	0	0
Other	1381	1186	1344	1186	2725	2372	1186	1186	1186	1186	1186	1186	8460	8302	158
Total	2509	2131	2539	2131	5048	4262	2131	2131	2131	2131	2131	2131	15325	14917	408
Agriculture WA															
Salaries	287	281	270	281	557	562	281	281	281	281	281	281	1956	1967	-11
Capital	0	0	0		0	0							0	0	0
Other	317	319	372	372	689	691	319	315	285	275	265	215	215	2046	2046
Total	604	600	642	653	1246	1253	600	596	566	556	546	496	4002	4013	-11
NT Dept Primary Industry & Fisheries															
Salaries	267	211	276	211	543	422	211	211	211	211	211	211	1542	1477	65
Capital	0	0	0		0	0							0	0	0
Other	150	152	166	152	316	304	152	152	152	152	152	152	1078	1064	14
Total	417	363	442	363	859	726	363	363	363	363	363	363	2620	2541	79
The University of Sydney															
Salaries	171	130	136	130	307	260	130	130	130	130	130	130	916	910	6
Capital	0	0		0	0								0	0	0
Other	295	224	235	224	530	448	224	224	224	224	224	224	1579	1568	11
Total	466	354	371	354	837	708	354	354	354	354	354	354	2495	2478	17
The University of New England															
Salaries	467	292	502	292	969	584	292	292	292	292	292	292	2254	2044	210
Capital	0	0	0		0	0							0	0	0
Other	230	221	236	221	466	442	221	221	221	221	221	221	1562	1547	15
Total	697	513	738	513	1435	1026	513	513	513	513	513	513	3816	3591	225
CRDC															
Salaries	70	62	69	62	139	124	62	62	62	62	62	62	441	434	7
Capital	0	0	0		0	0							0	0	0
Other	44	39	43	39	87	78	39	39	39	39	39	39	277	273	4
Total	114	101	112	101	226	202	101	101	101	101	101	101	718	707	11
Cotton Seed Distributors															
Salaries	182	113	151	113	333	226	113	113	113	113	113	113	829	791	38
Capital	0	0	0		0	0							0	0	0
Other	208	134	174	134	382	268	134	134	134	134	134	134	978	938	40
Total	390	247	325	247	715	494	247	247	247	247	247	247	1807	1729	78
Queensland Cotton															
Salaries	35	31	7	31	42	62	31	31	31	31	31	31	193	217	-24
Capital	0	0	0		0	0							0	0	0
Other	27	25	6	25	33	50	25	25	25	25	25	25	156	175	-19
Total	62	56	13	56	75	112	56	56	56	56	56	56	349	392	-43

PARTICIPANT	EXPENDITURE 2000/01 Actual	EXPENDITURE 2000/01 Agr'mt	EXPENDITURE 1999/00 Actual	EXPENDITURE 1999/00 Agr'mt	EXPENDITURE CUMULATIVE TOTAL TO DATE Actual	EXPENDITURE CUMULATIVE TOTAL TO DATE Agr'mt	PROJECTED EXPENDITURE 2000/01 Agr'mt	2001/02 Agr'mt	2002/03 Agr'mt	2003/04 Agr'mt	2004/05 Agr'mt	2005/06 Agr'mt	GRAND TOTAL Total 7 years	GRAND TOTAL Agr'mt 7 years	GRAND TOTAL Diff 7 years
Western Agricultural Industries															
Salaries	70	68	52	68	122	136	68	68	68	68	68	68	460	476	-16
Capital	0	0	0		0	0					0	0	0		
Other	66	57	46	57	112	114	57	57	57	57	57	57	388	399	-11
Total	136	125	98	125	234	250	125	125	125	125	125	125	848	875	-27
Twynam Cotton															
Salaries	0	120	157	120	157	240	120	120	120	120	120	120	877	840	37
Capital	0	0	0		0	0					0	0	0		
Other	0	65	101	65	101	130	65	65	65	65	65	65	491	455	36
Total	0	185	258	185	258	370	185	185	185	185	185	185	1368	1295	73
TOTAL IN-KIND CONTRIBUTIONS															
Salaries	5707	4553	5267	4521	10974	9074	4553	4532	4516	4516	4516	4516	32416	31670	746
Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	5422	4608	4853	4633	10275	9241	4608	4587	4537	4527	4517	4467	32096	31876	220
GRAND TOTAL (IN-KIND) (T1)	11129	9161	10120	9154	21249	18315	9161	9119	9053	9043	9033	8983	64512	63546	966

CASH CONTRIBUTIONS (DOLLARS IN '000s) TABLE 2

ATTACHMENT C

PARTICIPANT	ACTUAL 2000/01 Actual	ACTUAL 2000/01 Agr'mt	ACTUAL 1999/00 Actual	ACTUAL 1999/00 Agr'mt	CUMULATIVE TOTAL TO DATE Actual	CUMULATIVE TOTAL TO DATE Agr'mt	PROJECTED 2000/01 Agr'mt	2001/02 Agr'mt	2002/03 Agr'mt	2003/04 Agr'mt	2004/05 Agr'mt	2005/06 Agr'mt	GRAND TOTAL Total 7 years	Agr'mt 7 years	Diff 7 years
CRDC Cash Contrib.	350	350	350	350	700	700	350	350	350	350	350	350	2450	2450	0
Cotton Seed Distrib.	300	300	300	300	600	600	300	300	300	300	300	300	2100	2100	0
Twynam Cotton	25	50	50	50	75	100	50	50	50	50	50	50	350	350	0
Uni. of New England	0	0	100	100	100	100	0	0	0	0	0	0	100	100	0
TOTAL CASH FROM PARTICIPANTS	675	700	800	800	1475	1500	700	700	700	700	700	700	5000	5000	0
NSW Government	0	0	95	0	95	0	0	0	0	0	0	0	95	0	95
Qld Government	591	0	841	0	1432	0	0	0	0	0	0	0	841	0	841
Other	45	0	14	0	59	0	0	0	0	0	0	0	14	0	14
Other (eg Interest)	48	0	44	0	92	0	0	0	0	0	0	0	44	0	44
External Grants	247	0	303	100	550	100	0	0	0	0	0	0	303	100	203
CRDC Grants	1227	652	995	970	2222	1622	652	448	0	0	0	0	2095	2070	25
OTHER CASH	2158	652	2292	1070	4450	1722	652	448	0	0	0	0	3392	2170	1222
CRC GRANT	2200	2200	2000	2000	4200	4200	2200	2200	2100	2100	1800	1000	13400	13400	0
TOTAL CRC CASH CONTRIBUTION (T2)	5033	3552	5092	3870	10125	7422	3552	3348	2800	2800	2500	1700	21792	20570	1222
Cash carried forward	643	891													
Less Unspent Balance	1332	1562													
TOTAL CASH EXPENDITURE (T3)	4344	3552	4421	3870	8765	7422	3552	3348	2800	2800	2500	1700	21121	20570	551
ALLOCATION OF CASH EXPENDITURE BETWEEN HEADS OF EXPENDITURE															
SALARIES	3045	2615	2997	2394	6042	5009	2615	2585	1915	1730	1795	1232	14869	14266	603
CAPITAL	58	0	167	0	225	0	0	0	0	0	167	0	167	0	0
OTHER	1241	1042	1258	1083	2499	2125	1042	1022	898	899	847	512	6478	6303	175
TOTAL EXPENDITURE	4344	3657	4421	3477	8765	7134	3657	3607	2813	2629	2642	1744	21513	20569	944

SUMMARY OF RESOURCES APPLIED TO ACTIVITIES OF CENTRE (DOLLARS IN $'000's) TABLE 3

ATTACHMENT C

	ACTUAL		ACTUAL		CUMULATIVE		PROJECTED						GRAND TOTAL		
	2000/01		1999/00		TOTAL TO DATE		2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	Total	Agr'mt	Diff
	Actual	Agr'mt	Actual	Agr'mt	Actual	Agr'mt	Agr'mt	Agr'mt	Agr'mt	Agr'mt	Agr'mt	Agr'mt	7 years	7 years	7 years
GRAND TOTAL (IN-KIND) FROM TABLE 1 (T1)	11129	9161	10120	9154	21249	18315	9161	9119	9053	9043	9033	8983	64512	63546	966
GRAND TOTAL (CASH EXPENDITURE) FROM TABLE 2 (T3)	4344	3552	4421	3870	8765	7422	3552	3348	2800	2800	2500	1700	21121	20570	551
TOTAL RESOUR. APPLIED TO ACTIVITIES OF CENTRE (T1+T3)	15473	12713	14541	13024	30014	25737	12713	12467	11853	11843	11533	10683	85633	84116	1517
ALLOCATION OF TOTAL RESOURCES APPLIED TO ACTIVITIES OF CENTRE BETWEEN HEADS OF EXPENDITURE (CASH AND IN KIND)															
TOTAL SALARIES (CASH AND IN-KIND)	8752	7168	8264	6915	17016	14083	7168	7117	6431	6246	6311	5748	47285	45936	1349
TOTAL CAPITAL (CASH AND IN-KIND)	58	0	167	0	225	0	0	0	0	0	0	0	167	0	167
TOTAL OTHER (CASH AND IN-KIND)	6663	5650	6111	5716	12774	11366	5650	5609	5435	5426	5364	4979	38574	38179	395

ALLOCATION OF RESOURCES BETWEEN CATEGORIES OF ACTIVITIES TABLE 4

ATTACHMENT C

	RESOURCE USAGE					
PROGRAM	$ Cash ('000)		$ In-Kind ('000)		Contributed Staff	Cash Funded Staff
Research	2230.1	51.3%	8243.0	74.1%	35.6	22.3
Education	523.0	12.0%	501.0	4.5%	1.5	1.3
External Communications	0.6	0.0%	7.0	0.1%	0.0	0.5
Technology Transfer	1075.5	24.8%	2378.0	21.4%	16.4	11.9
Administration	514.8	11.9%	0.0	0.0%	0.0	2.3
TOTAL	**4344.0 (T3)**		**11129.0 (T1)**		**53.4**	**38.3**