Part 1 - Summary Details

Please use your TAB key to complete Parts 1 & 2.

CRDC ID: CRC93 **Cotton CRC Project Number: 5.03.02**

Project Title: Delivering Science to Agribusiness: Cotton Management Support Systems

Project Commencement Date: 01/07/2005 **Project Completion Date:** 30/06/2007

CRDC Program: Capacity & Community **CRC Program:** The Adoption

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Final Report

Background

Cotton growers continue to face increasing pressure to manage resources more cost effectively and to be more accountable for the impact their decisions have on the surrounding environment. In addition to this there are significant changes in technology such as new transgenics (Bollgard II and Roundup Flex) and an increasing need to improve fibre quality and water use efficiency. There was a dedicated commitment by research organisations in the industry (CSIRO, CRDC and Cotton CRC) to develop tools and techniques for decision making from the best information available from research to help all sectors of the industry to meet crop production, social and environmental imperatives. The Australian cotton industry is considered world leaders in developing and using advanced decision tools to optimise crop management, improve profitability and reduce environmental impacts.

A range of Decision Support Systems (DSS) developed and supported by the CSIRO Plant Industry Cotton Management Support Systems team located in Narrabri were available to assist industry with crop management at the start of this project. They include, CottonLOGIC (HydroLOGIC, EntomoLOGIC, and NutriLOGIC delivered over PC, web and handheld systems), the CRC website, amongst other research based tools. A business plan commissioned by the CRDC before the start of this project supported the redevelopment of CottonLOGIC DSS to meet the current and future needs of the industry. The plan also outlined that the current strategy of the CSIRO team developing these tools was highly efficient and successful and the industry should maintain support for this initiative. Other recommendations included the need to seek opportunities where these tools are more valued by the users. One suggestion was to include the use of the decision tools as part of accredited training courses already being conducted in the industry.

Existing decision support tools at the start of this project included:

- CottonLOGIC – Pest management, nitrogen nutrition management, data recording and analysis (Over 1200 were last distributed in 2003).
- CottonLOGIC for Palm OS ® – In field electronic data recording and decision tools. Recent additions to this tool have included whitefly sampling and the ability to GPS data.
- OZCOT – user friendly version used by extension personnel and APSRU's Commercial FARMSCAPE initiative. OZCOT is also extensively used in research.
- HydroLOGIC – Tactical and strategic water management tool – formally released November 2003. Five hundred copies have been distributed to industry on request. Over 240 people have attended training sessions on the use of HydroLOGIC for irrigation management.
- WUEcalc – Field and whole farm WUE calculator used by extension personnel –major components have been incorporated into HydroLOGIC.
- Cotton CRC's website – aims to be central repository of research based information generated by the CRC and its participating organisations.
- CottonLOGIC tools on the web – Located on the Cotton CRC's website, it includes crop decision tools: NutriLOGIC, Early season diagnosis tool, and the CRC day degree calculator.

- Cotton CRC's industry database – developed by the Cotton management support systems team and used to distribute extension material. Some example of recent developments on the CRC website involved the staff database and the interactive cotton pest and beneficial guide.
- Scenario Generator – A tool for researchers to use as a front end to the OZCOT crop simulation model to give them the ability to run multiple simulations and store them in a database for further analysis.

An important element of this project was to continue to identify critical issues where decision support tools can help including growers and consultants to address key industry issues to maintain industry sustainability. We had a range of new ideas and also requests from industry that need to be progressed over the next few years. This project also maintained and supported the existing software packages to ensure their ongoing relevance and performance. Finally, this project provided support for researchers, such as developing programs to help with validation of models or present data on the WWW. The approach we proposed to achieve this is to combine dedicated programmers, to ensure that the most up-to-date software design and web management is used, with experienced cotton agronomists Ms Sandra Deutscher and Dirk Richards, to undertake field validation of software and to understand technical issues from the industry's point of view when developing new tools. Dr Bange helped to provide critical linkages with other researchers throughout the industry which is an important source of ideas and knowledge to assist development.

This project combined two projects previously supported by the CRDC and one by the Cotton CRC that contributed to the development of decision tools for the cotton industry. This project alone was the principle project that supported the cotton industry's investment in decision support development.

Specifically the project supported:

- The salary of Ms Sandra Deutscher, Experimental Scientist responsible for field validation, software evaluation and testing, as well as providing software training and support. Sandra's role was to assist in implementing advanced computing approaches for delivery of information, such as using multi-format tools that allow rapid publication of Web, hardcopy and CD based information.

- The salaries of experienced software developers Mr Darren Linsley (previously supported by CRDC project 'Supporting Development and Independent Evaluation of Cotton Management Packages' and Laxmi Thakur (previously supported by Cotton CRC jointly funded with the CRC titled 'Delivering Science to Agribusiness – Novel Decision Support Tools'. If the new CRC was to be successful it may consider supporting the salary of Ms Thakur (Now Loretta Clancy) for the remainder of the project.

- Operating costs to fund the necessary resources for new software engineering projects, field validation, essential IT training, support, and the production and distribution of software. This project had a special emphasis on redeveloping CottonLOGIC (to meet the futures needs of the industry.

Further specific details of our strategy for DSS including OZCOT development are available online at www.cotton.crc.org./CottonLOGIC/.

Objectives

The focus of the Cotton Management Support Systems Team was to take a leading role in ensuring that good science is passed on easily and effectively to the industry to assist with complex decisions. Some outcomes of science can be delivered affectively via written documents, but increasingly there is a demand for more interactive information delivery that enables growers to tailor the information to their need and also in the rapidly changing world for up-to-date information. The aims of the project were to:

1. Interact with researchers, extension personnel and industry to identify critical issues where decision support tools can help growers and consultants.
2. Investigate innovative ways to process, integrate and present the complex research outcomes to provide these tools and facilitate efficient delivery and updating of this information on different media (written, CD, WWW).
3. Provide support for researchers and to facilitate industry involvement in the development of computer decision support.
4. Maintain and support existing software packages to ensure their ongoing development, relevance and performance.
5. Continue evaluating the impact and nature of use of computerised decision support in the Australian cotton industry to assist in planning and future development of these capabilities.

Table 1: List of objectives and Milestones achieved during the course of the project.

Obj No.	Objective	Milestone	Performance Indicator	Yr 1	Yr 2	Achieved
1	**In consultation with CRC/CRDC develop a strategic/business plan for development and delivery of cotton decision support**	**Successfully develop a strategic/business plan**	**Final plan presented to relevant key industry stakeholders and project milestones reviewed by June 2006**	✓		✓
2	**Develop tools to assist the management of Bollgard II crops**	**Field validate existing early season diagnosis tool and make changes to web based tool**	**Changes to web based early season tool completed and delivered to industry**	✓		✓
3	**Prototype a new CottonLOGIC to capture industry needs**	**Successfully completed a prototype version of a redeveloped CottonLOGIC**	**Feedback documented on the future need for full version of CottonLOGIC**	✓		✓
4	**Redevelop CottonLOGIC software components**	**Successful redevelopment of operations and observation components of**	**CottonLOGIC suite formally released to industry.**		✓	**Software developed but not delivered**

		CottonLOGIC software				**to industry**
5	**Improve capability of HydroLOGIC software for irrigation management decisions**	**Successful upgrade of HydroLOGIC to improve reporting and use with other irrigation systems**	**HydroLOGIC upgrade distributed to industry**	✓	✓	✓

6	**Maintain functionality and improve Cotton CRC website capabilities**	**Continuous availability of website and improved capability including survey capabilities and new CottonLOGIC website**	**Frequent use and expanded capability of website used by industry**	✓	✓	✓
8	**Use models from HEAPS and information from other sources to provide decision support tools for trap crops, refuges and management of *Helicoverpa* on them**	**Complete redevelopment of HEAPS using the common modelling protocol.**	**Develop a facility on the web site to provide dates of *Helicoverpa* diapause induction for each region using real weather data.**		✓	✓
9	**Upgrade handheld version of CottonLOGIC**	**Successfully developed software for new versions of Palm operating systems and Pocket PC environments**	**Software delivered to industry**	✓		**Software developed but not delivered to industry**
10	**Provision of software support**	**Successful delivery of phone support help desk through the CRC's Technology resource centre.**	**Record of logged calls and problems listed in bug tracking software and issues resolved.**	✓	✓	✓
11	**Provision of training in decision support**	**Successfully deliver training workshops for decision support**	**Workshops held in each region and workshop evaluation documented**	✓	✓	✓

Note: Our capacity to achieve was limited by the severe restrictions in operational funds during the course of this project.

Methods

This project built on existing tools and software infrastructure and developed new infrastructure in the case of CottonLOGIC, but also exploited opportunities to develop a range of smaller focussed tools delivered by CD or the Web, and to further the development of some existing tools that are currently not being used effectively, such as HEAPS. Decisions on what to develop had come from feedback from our Decision Support Advisory

Committee and from interactions with other researchers and members of industry organisations such as TIMS and the Cotton CRC WUE group.

Results

This project supported the overall effort of the CSIRO Plant Industry Cotton Management Support Systems team based in Narrabri. Financial support was also provided by CSIRO Plant Industry and the Cotton CRC. A brief outline of the major results and outcomes from this project are given below:

Delivery of an Operational Plan for DSS development

In the first year of the project in consultation with CRDC, the CRC and industry an operational plan was developed for the Cotton Management Support Systems Team. The plan had the following aims:

- Define the role of the Cotton Management Support Systems Team for delivery of cotton decision support for industry in light of current industry feedback, surveys and business plan commissioned by the CRDC.
- In conjunction with an industry working group develop agreed approaches on attaining industry feedback and direction setting of decision support development.
- Outline strategies for delivery of decision support to industry including involvement with other industry (3rd party) interests.
- Define investment/resources required by the Cotton Management Support Systems Team needed to deliver outcomes.

The executive summary (Sep 2006) of the plan follows:

The Australian cotton industry is a world leader. However, the industry faces opportunities, challenges and complexities in the form of new technologies (telecommunications / transgenics) and the need to enhance fibre quality and improve management of inputs (water, pesticides, nutrition). Continued success will be underpinned by extending research information to optimise crop management, improve profitability and reduce environmental impacts. The Cotton Management Support Systems Team based in Narrabri has evolved to meet these challenges. The team includes specialist scientists focused on extending research as well as dedicated software developers, and also brings in the skills of research scientists where necessary. This operational plan recognises the need to ensure that the Team is able to work effectively with industry to identify opportunities and priorities for decision support and extension and to ensure seamless delivery to and uptake by industry.

The team's mission is to develop, validate and deliver to the cotton industry up-to-date and scientifically grounded decision tools and extension information packages that are accepted as the benchmark for improving the profitability and sustainability of cotton production. In achieving this aim it is critical that the selection of priority areas for effort is based on constructive feedback from industry customers and stakeholders, especially from the industry Steering Group. Given that cotton growers, agronomists and consultants also use other decision tools or software, e.g. financial or record keeping, it is also essential that the tools

developed can share data and link with other software packages to minimize double handling of information.

There are many critical issues facing the cotton industry, ranging from drought and water supply; yield and profitability; fibre quality and export price; nutrition; and sustainability - catchment management. As a result of this complexity, extension is also complex – with a limited IDO network at a time when extension of the above issues is more important. Extension can take many forms and involve scientists, IDO's, consultants and commercial-retail (e.g. seed companies). Delivery can be via field days, conferences, written materials ('paks' and newsletters), programs ('LOGICS'), handheld computer tools and web information or applications. Our team operates at all levels of extension delivery.

The structure and operation of the team has been changed to address future challenges in three ways:

- Internally, CSIRO management will play a more active role in establishing and running extension projects. Teams involving research, extension and software developers (where relevant) will be established for each initiative.
- Project structure will be modified to more clearly distinguish between extension and software development. Sandra Deutscher and Dirk Richards will play a pivotal role in ensuring this process succeeds by facilitating researcher involvement and directly participating in extension initiatives as active members of the industry's extension focus teams. This is distinct from investment in software development.
- Importantly, an industry Decision Support Steering Group is being established to enlist input from industry on directions and priorities, provide feedback on decision support initiatives and to engender greater ownership and adoption of decision support initiatives within the industry. The Group have already met once to discuss and agree to this process

The operational plan builds on existing expertise and tools, and develops new infrastructure in the case of software and the web, while exploiting opportunities to develop new extension packages. Opportunities that may be considered for the future include subjects such as water use and efficiency; fibre quality; nutrition; pest management; and closer association with the BMP process.

Redevelop CottonLOGIC and EntomoLOGIC to meet future needs of the industry.

Despite CottonLOGIC still being widely used further development of the current version of CottonLOGIC ver. 5.00 software released in 2002 in no longer feasible or cost effective. A new CottonLOGIC was to be redeveloped to meet the future needs of the industry.

The CottonLOGIC software infrastructure was redeveloped to allow to the development of new CottonLOGIC suite of decision support tools. The new CottonLOGIC Suite was to be a collection of decision support applications which are independent of each other, but through the CottonLOGIC Decision Support Framework were able to leverage off one another (e.g. data sharing and functionality). The CottonLOGIC Decision Support Framework allowed us to encapsulate concepts and functionality, essentially creating a toolkit of reusable software components. It is these software components we use to develop the decision support applications. Key features of the CottonLOGIC Suite/Decision Support Framework were:

- A modular approach to software development that provides as much flexibility as possible. This will help us accommodate changes a lot better.
- The ability to develop independent applications capable of sharing data and functionality
- The ability to develop decision support applications that can be delivered across different and/or multiple platforms (PC, Handheld, www) more easily
- Encapsulating the science models into discrete units separate from the applications (promotes better code reuse)
- Creating enhanced integration of internet-enabled technologies
- Providing a consistent "look & feel" across our suite of decision support applications
- Using a new Visual Studio .NET style of user interface (more windows compatible)

EntomoLOGIC is a decision support application designed to assist in the decision making processes of integrated pest management (IPM) in cotton. We will be redeveloping EntomoLOGIC using the new CottonLOGIC infrastructure as part of the CottonLOGIC suite to support current and future IPM practices. Key features included:

- Increased general flexibility. Where appropriate and possible the user can customise the application to suit their individual approach to insect management.
- General improvements throughout the entire system sourced from our own user-feedback.
- New threshold strategies allow the user to create/modify and maintain their own insect thresholds either by crop development phase or stage.
- Improved operations system.
- Improved spray ordering system.
- Automatically detect product updates/upgrades via the internet.
- Enhanced data import/export capabilities. This will greatly streamline the "sharing" of data between consultants and growers.

Since the release of the handheld version of CottonLOGIC in 2002 there have been significant version changes in the operating systems of the Palm® handhelds. In addition there is also a significant increase in the number of Pocket PC handhelds being used across the industry. We had upgraded the handheld software to accommodate the new operating systems available. We were also seeking to develop other simple tools that were to be delivered on handhelds to assist data collection.

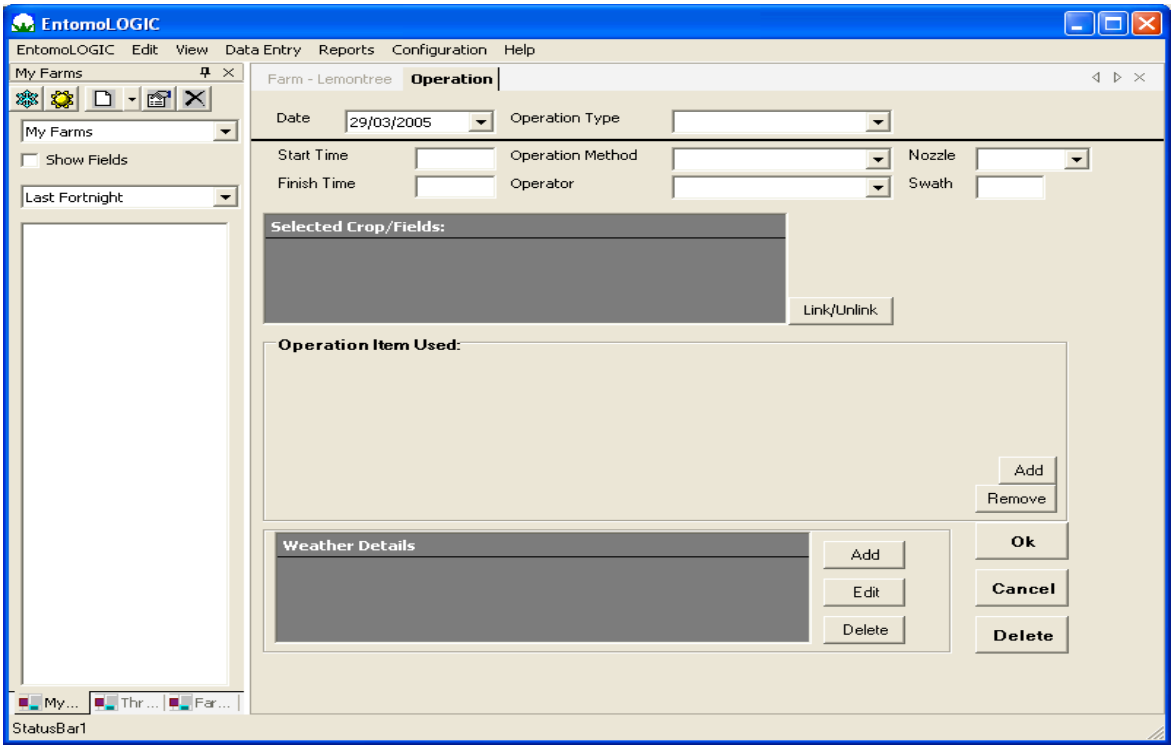

Figure 1: An example of new interface for EntomoLOGIC which was to be released Jun 2007.

Re-development of CottonLOGIC and EntomoLOGIC desktop and handheld software was on schedule. Importing and exporting routines for data sharing were complete. Complex aspects of the handheld scouting tool development were also completed. The only remaining development for June 2007 prototype release was completion of the user interfaces for data entry.

Due to the closure of the Cotton Management Support Systems team re-development of CottonLOGIC ceased May 2007.

Upgrade HydroLOGIC

Several new features in response to feedback from growers, consultants and researchers were implemented in HydroLOGIC, they included:

- Enhancing how an irrigation deficit can be defined for a particular scenario. There are now three options
- A single action was enabled for updating of all scenario run dates for a crop.
- Report Generation is now more streamlined and there are two new reports

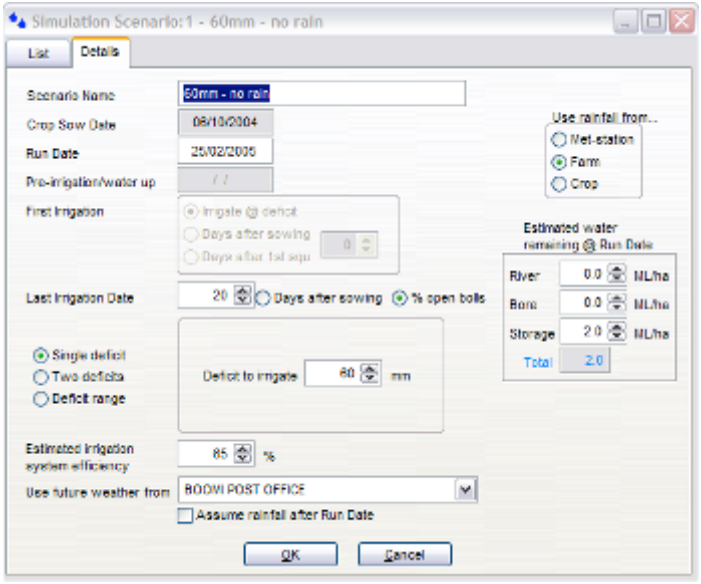

Figure 2: A screen shot of the HydroLOGIC scenario creation screen. Note the ability to change the number of deficits (a new feature).

We had also completed the specifications to enable HydroLOGIC to account for seasonal forecasts using the SOI and analogous climate years. These developments were linked to CRDC project 'Delivering science to agribusiness: smart approaches to irrigation management'.

Enhancing NutriLOGIC

A significant upgrade to NutriLOGIC on the web was completed. This upgrade improved the nitrogen management tools (leaf and petiole) (Figure 3) and allowed interpretation of other nutrients using leaf sampling (Figure 4). This information was also provided to Nutrient Management Systems (a Cotton CRC collaborator) as secured code for use in their Soilmate software for nutrient sample analysis.

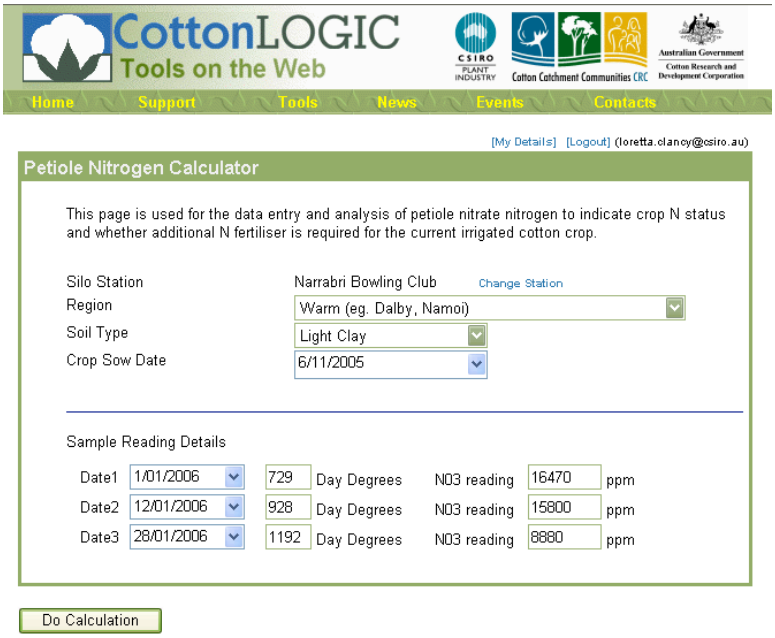

Figure 3: A screen shot of the upgraded NutriLOGIC for petiole nitrogen analysis. A significant feature is the linkages with the SILO day degree calculator to calculate day degrees to estimate the rate of change in petiole nitrogen needed for nitrogen requirements.

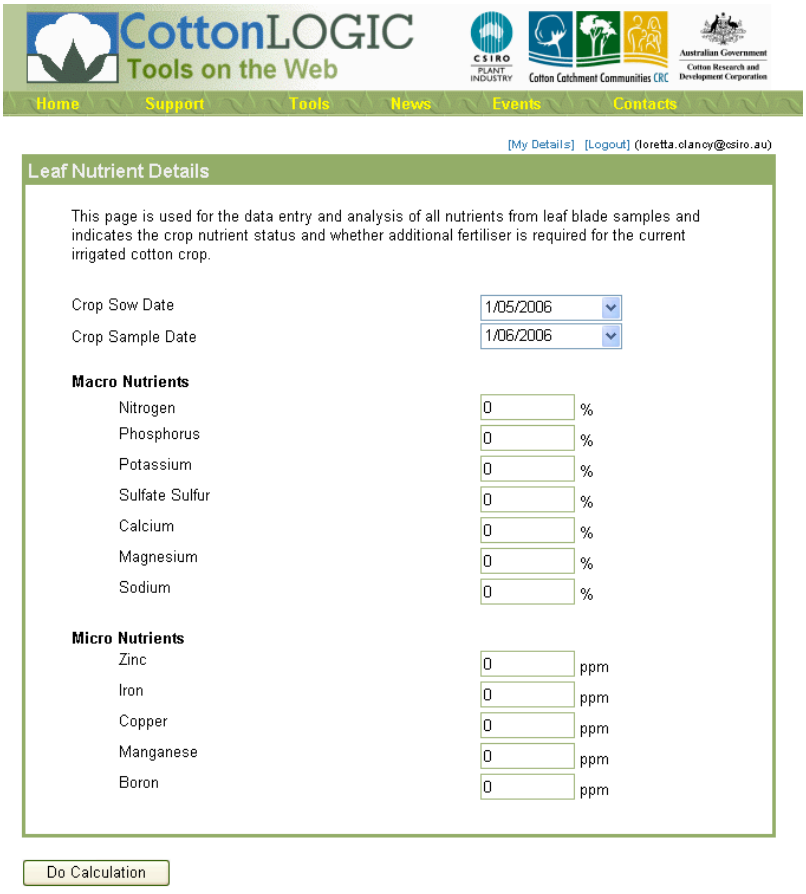

Figure 4: A screen shot of the upgraded NutriLOGIC for leaf nutrient analysis. A significant new feature is increase in the range of nutrients for assessing crop nutritional requirements.

Exploit the capabilities of the HEAPS model

HEAPS simulates Helicoverpa population growth and dispersal over a region, to specifically support resistance management for Bollgard II cotton and conventional insecticides. A number of specific tools to enable growers to forecast, using local weather, when particular trap or refuge crops need to be planted, allowing for different varieties, to estimate the development, pupation, emergence and diapause of Helicoverpa so that trap and refuge crops can be managed effectively and to forecast the % diapause and emergence date for cotton so better pest management and pupae busting decisions can be made. This is critical for Bollgard II, for which resistance management hinges on effective refuges and pupae control.

With the support if Dave Murray from Queensland DPI the decision support team completed a Helicoverpa spp. moth emergence and diapause calculator that has been released on the CottonLOGIC tools component of the Cotton CRC website. The tool enables users to predict timing of moth emergence and diapause induction (Figure 5) using recent weather data. It also allows the users to compare moth emergence and diapause induction with historical climatic averages and colder and hotter conditions. The calculator utilises the SILO patched point climate database provided by the BoM and QDNR.

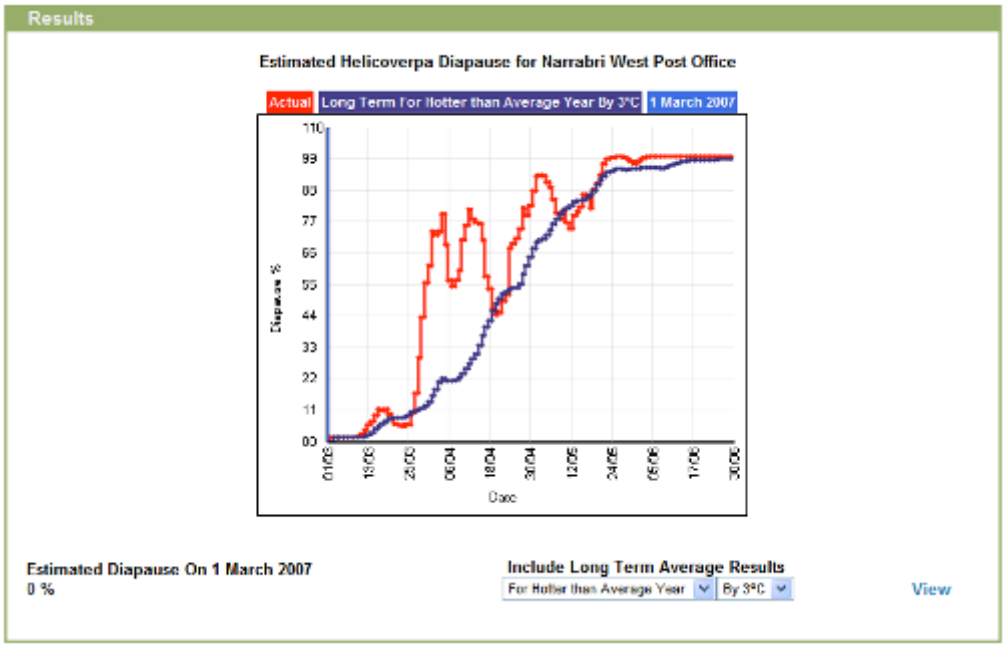

Figure 5: A screen shot of the *Helicoverpa* spp. diapause calculator link to the SILO patched point database.

Develop tools to assist with management of growth to optimise yield and quality of Bollgard II.

A major initiative carried out by the Cotton Management Support Systems Team to support the management of Bollgard II crops was to upgrade and field validate the Crop Development Tool (CDT).

The CDT was significantly upgraded. The first significant improvement was the ability of users to register so that they were able to enter data for multiple crops and this to be stored for later use (Figure 6). The second improvement was to allow users to enter fruit counts and

compare this with a potential fruit development curves (Figure 7). The final significant improvement was to allow users to assess the need for growth regulators (namely PIX®) (Figure 8).

Figure 6: A screen shot depicting the new ability in the CDT to enter multiple crops and to be able to access data for later use.

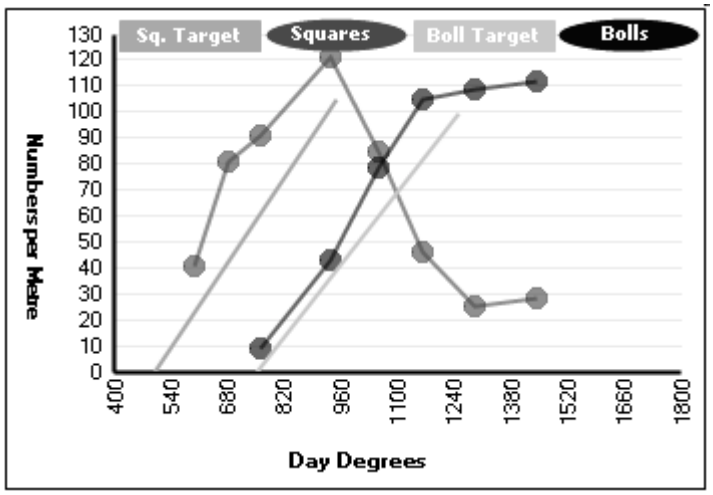

Figure 7: A screen shot depicting the new functionality in the CDT to enter fruit numbers and to make comparison to potential fruit growth rates.

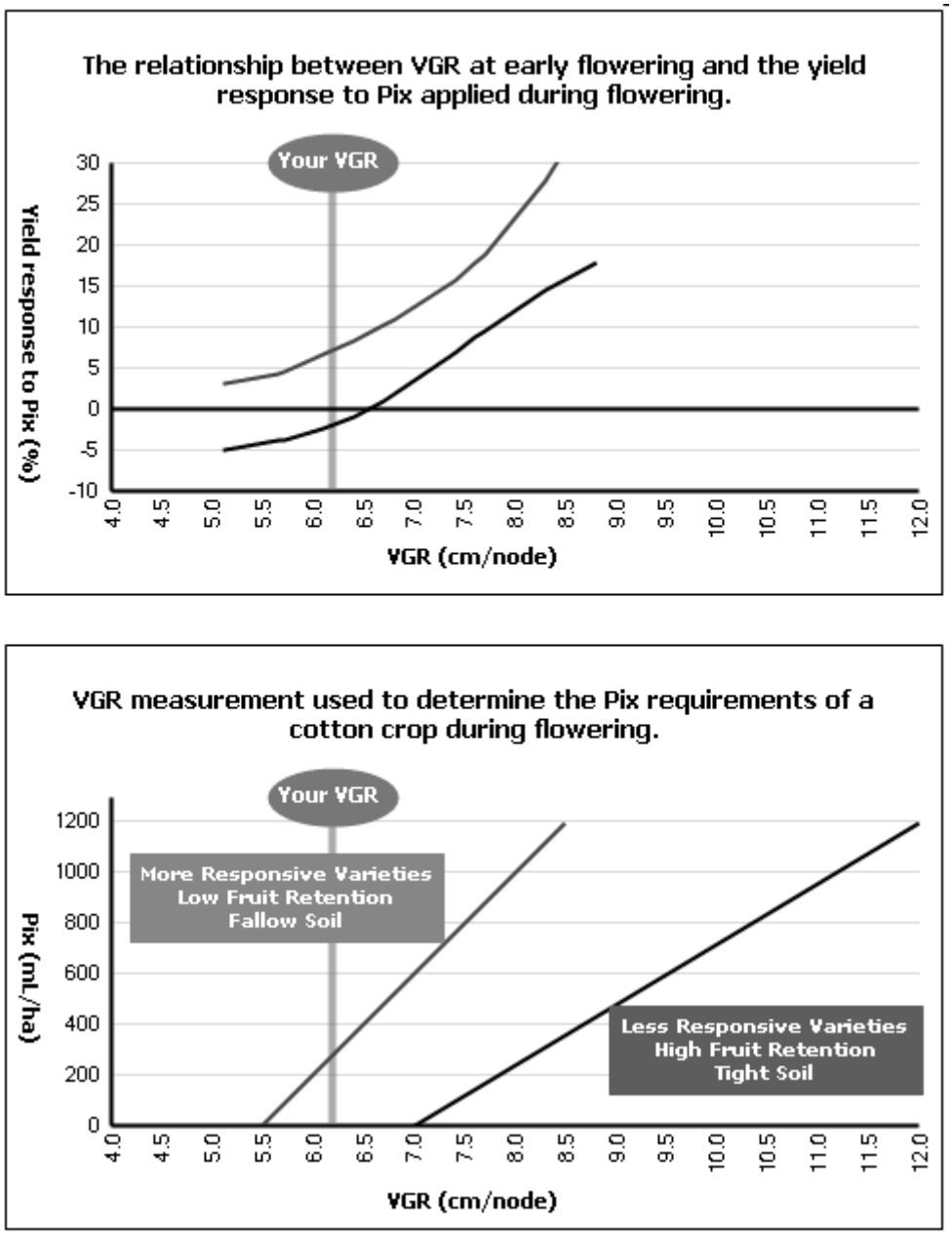

Figure 8: A screen shot depicting the new functionality in the CDT to calculate vegetative growth rate (cm/node) and compare this to the effect of yield to PIX application and recommendations for PIX rates.

During this project Sandra Deutscher conducted field experiments to test the functionality and ability of the CDT to detect cotton crop development differences under various management scenarios.

Experiments were designed to grow crops with different rates of crop development. In doing so, three different cotton crops with different growth habits (vigorous, normal and slow (Table 2) were grown over two seasons on fallow fields known to normally provide optimum yield and maturity with 150 kg N/ha. Sicot 289BR was sown in both seasons.

Table 2. Crop details of field validation trials for the crop development tool (CDT).

Crop Type	Management variable	2004/05	2005/06
Vigorous	Late sow date	04/11/2004	10/11/2005
	High N rate	275 kg/ha	280 kg/ha
Normal	Average sow date	22/10/2004	19/10/2005
	Average N rate (kg/ha)	150 kg/ha	140 kg/ha
Slow	Early sow date	06/10/2004	26/09/2005
	Low N rate (kg/ha)	60 kg/ha	0 kg/ha

Plots were monitored weekly, counting squaring nodes before flowering, nodes above the 1st position white flower (NAWF) after flowering, and square and boll counts throughout the season. Counts were entered into the CDT and compared with the potential. Management issues, if identified by the CDT, were resolved with guidance from other in-crop monitoring, including soil moisture, petiole nitrate, VGR, and visual assessments.

At the end of the season, maturity (days after sowing to 60% open bolls) and lint yields were measured.

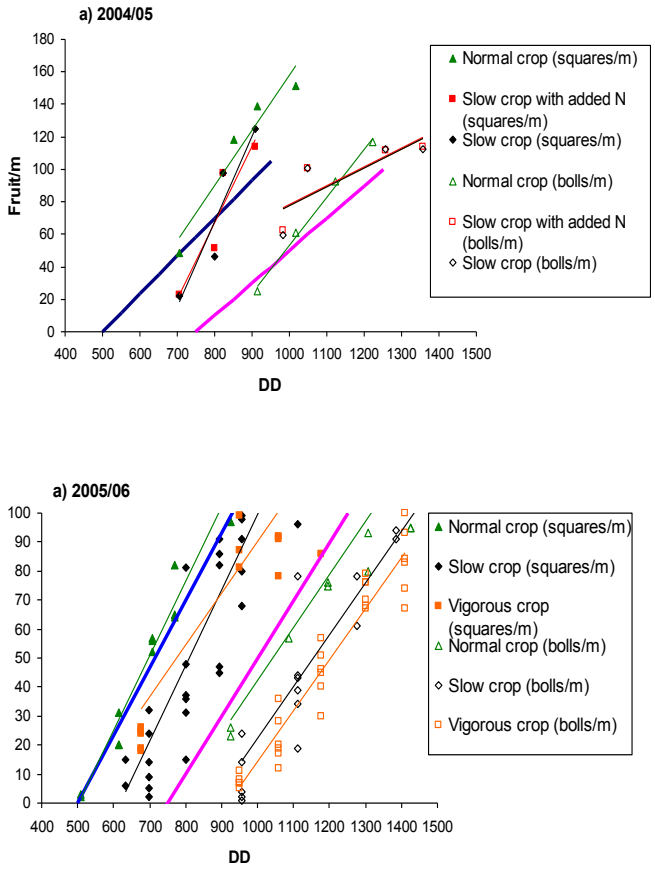

Figure 9. Tracking square and boll production in all crop types in (a) 2004/05 and (b) 2005/06.

CDT effectively tracked cotton development and represented changes in growth as a result of nitrogen and sowing date. The CDT also effectively tracked square and boll development

(Figure 9). Fruit counts that are found to be tracking below the theoretical target can be a useful prompt for the user to further explore the cause (e.g. pest pressure, water stress) and then manage as appropriate.

The diagnosis of cotton for fine tuning management cannot singly rely on the use of the CDT. It is very important to frequently monitor other aspects of crop growth and growing conditions. Keeping track of important crop inputs such as pest pressure, vegetative growth, nutrients and water is also fundamental in the diagnosis of cotton management.

The differences found in the rate of square and boll production between crop types in the 2004/05 season is potentially influenced by having only five measurements over the season which has caused outlying data points. This highlighted the need for consistent ongoing measurements throughout the season. The results of this study were published in the Australian Cottongrower magazine.

Water Quality Calculator

During the course of this project a web tool that can be used to calculate the salinity (EC), Sodium Adsorption Ratio (SAR) and pH when water sources are mixed together to provide irrigation water was developed. The calculated figures are then compared with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and reference information contained in the Cotton CRC WaterPak publication (Figure 10).

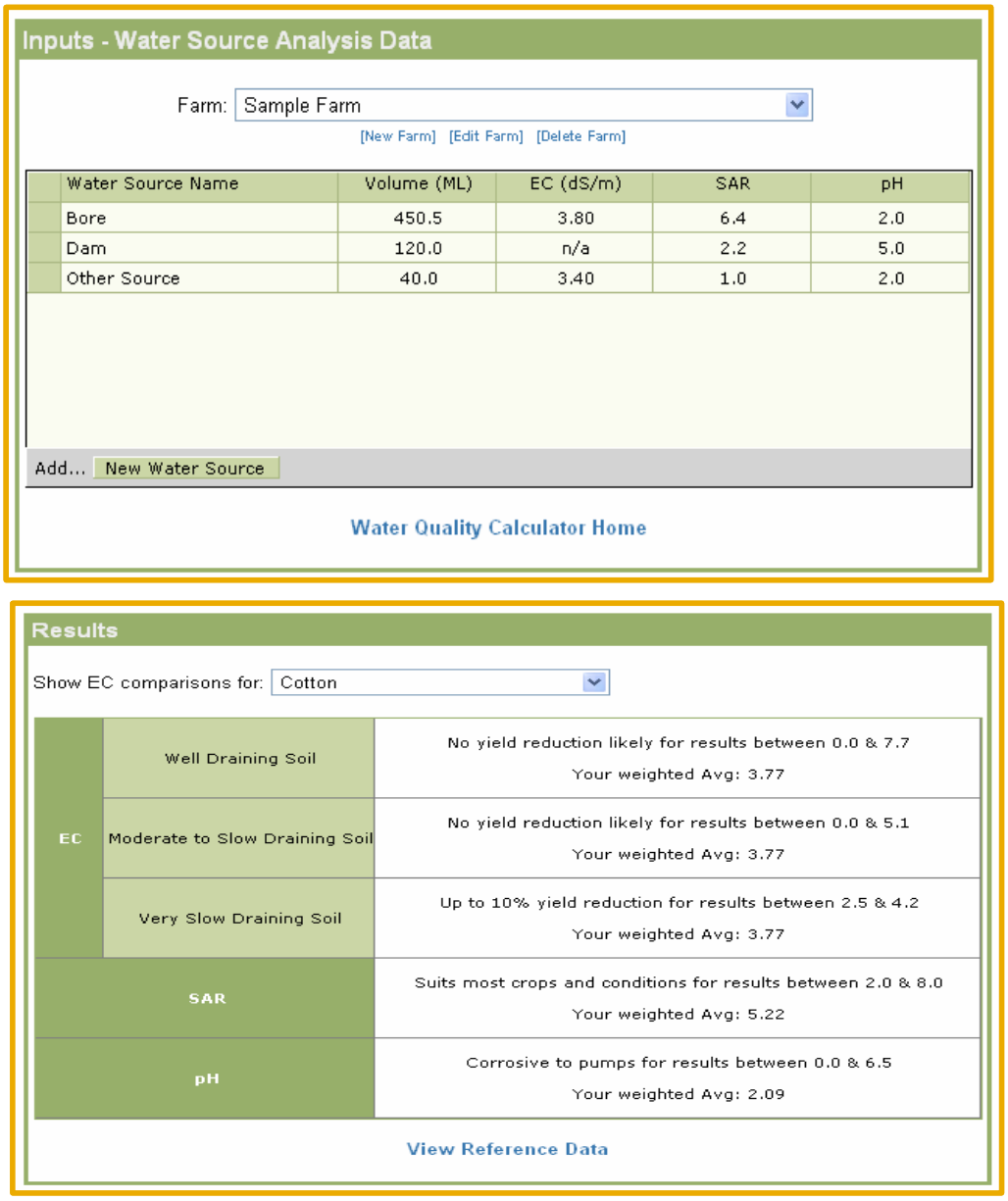

Figure 10: A screen shot of the water quality calculator used to estimate irrigation water quality.

This development was linked to CRDC project 'Delivering Science to Agribusiness: Smart Approaches to Irrigation Management'. The water quality calculator is being promoted through the Cotton CRC's soil health workshops being coordinated by Helen Squires.

Development of 'CottBASE'

Farm enterprise and crop management decisions will be exposed to risk through the effect of seasonal climate variability on crop yield, market uncertainty, and other sources of risk. During the course of this project a database tool containing pre-run simulation output from OZCOT was developed. CottBASE combines seasonal forecasting and historical climate records with crop modelling to predict the production risk that irrigated cotton growers may

expect under different management practices. CottBASE may help producers to choose the best management options for the next season, with an understanding of risks involved.

The CottBASE databases were created using the OZCOT cotton crop simulation model (CSIRO Plant Industry), to simulate a range of scenarios with different starting soil conditions and management options. Each combination of district, sowing date, starting soil conditions, etc., defines a single simulation (Figure 11). Each simulation is as long as the historical climate records available for that site. This data has been collected over the last 50 years, and in some instances, 100 years.

CottBASE can be used to explore 'what if?' decisions based around soil water holding capacity, soil water at sowing, crop type, time of sowing, Soil N content, N fertiliser rate, irrigation options and SOI phase effects on likely yield, and the level of risk associated with a simulation choice (see example Figure 12). For each prediction of crop growth, a range of crop variables are generated, including dates of crop development, evapotranspiration, crop water balance and potential yield (bales per hectare). The software will be made available to the Cotton CRC's extension team.

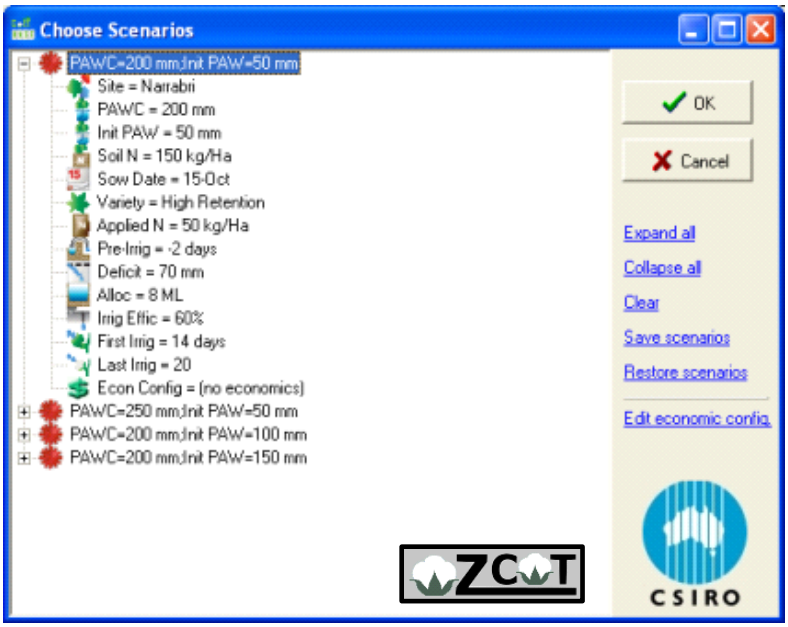

Figure 11: A screen shot of the CottBASE software showing the range of options to access pre-run simulations of OZCOT for different management scenarios.

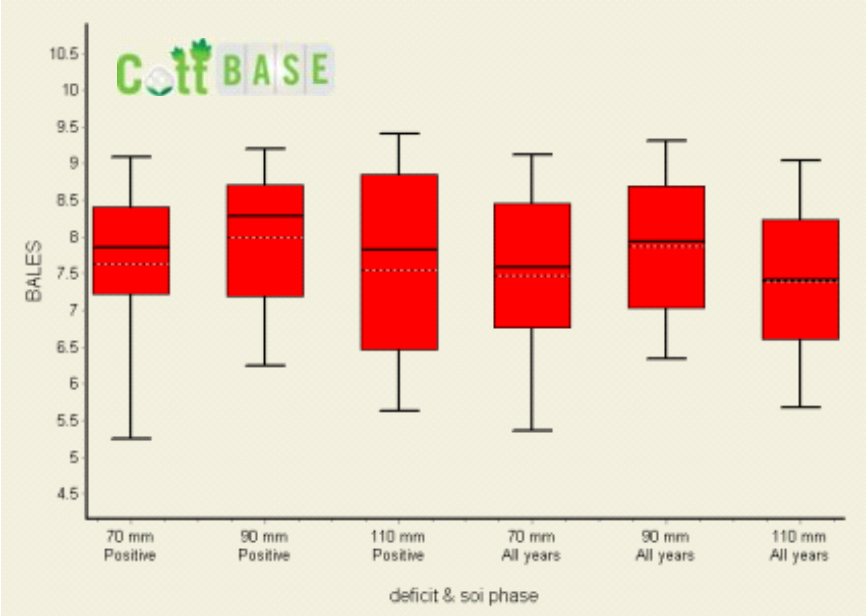

Figure 12: An example of output that can be generated from CottBASE. This example shows the variability in yield for a range of irrigation deficits for a positive SOI phase (climate forecast) compared with average generated from all years' data.

Enhance and maintain Cotton CRC website infrastructure

During this period Loretta Clancy of the decision support team helped a small team from the CRC to scope the requirements for a new Cotton Catchment Communities CRC website. Loretta's role was to provide technical input with respect to possible software needed for development and ongoing maintenance, and to provide a recommendation for implementation.

Specifically Loretta helped with: an evaluation the existing web site and discussions with stakeholders to determine requirements for new site; sourcing a variety of possible providers with different implementation solutions. These varied from standard web page development through to a complete Content Management System (CMS) solution. Many discussions, both verbal and via email, were held with all solution providers and their technical staff, to determine the merits of each possible solution, with particular focus being placed on the usability and ongoing maintainability of the website by CRC staff. After negotiating possible implementation timeframes and costings, Loretta provided recommendations to the CRC board which were accepted and adopted.

Facilitate an industry advisory committee

To provide direction and feedback on decision support systems a decision support industry advisory group was established. During the course of this project this committee met twice. Representation on this committee comprised of members from various sectors in order to provide better communication between the DSS/extension team and industry. The advisory group had representatives from:

- Australian Cotton Growers Research Association

- Cotton Consultants Australia
- Cotton Australia
- Education
- Cotton Research and Development Corporation
- Cotton Catchments' Communities CRC
- CSIRO

The first meeting of this group was held on 17th July 2006. Expectations of the group's roles were documented and are presented in Table 4.

Table 3: Expectations identified by the decision support advisory group and votes for each.

Expectation	***Vote #***
To identify and prioritise new areas for DSS investment	10
To provide advice, direction and feedback	9
To help develop a process of evaluation - setting targets for DSS use and critical analysis.	8
To provide feedback to us about industry initiatives	7
To represent your organization	6
To identify effective delivery mechanisms	5
To have ownership over the direction of DSS and support this	4
To identify effective ways to support and train users	4
As a source of engagement with industry	1
To help develop useful, cost efficient, integrated DSS (The challenge here is to find the wisdom to do this)	1
As a point of contact for DSS issues	
To encourage the integration of extension sources	

The role of the advisory committee has finished with the cessation of the Cotton Management Support Systems team. A final task that the group contributed to was establishing a priority list for website upgrade of the remaining decision support web tools. The priorities identified were the crop development tool, NutriLOGIC and the day degree calculator.

Training and Support

Successful uptake of decision support tools requires support. A phone help desk for decision support was provided as part of the role of the CRC's Technology Resource Centre. Members of the Cotton Management Support Team actively supported the decision tools by manning a phone support desk. Calls were logged and problems often rectified. In some instances members of the team meet with users 'one on one' to resolve their individual problems. Provision of software support has been a crucial link to industry to provide necessary feedback for decision tool development.

Every year, in each of the cotton valleys, dedicated training workshops are conducted by the Cotton Management Support Systems Team. These workshops provide essential training in the use of cotton decision tools. They also serve as an important mechanism to provide industry feedback on the use of the tools. This project provides the necessary resources to conduct these workshops.

During the September 2005, Dirk Richards and Sandra Deutscher organized and conducted eleven training workshops throughout NSW and QLD, with 65 growers, consultants and agronomists attending. These workshops aimed to demonstrate the newly developed web tools, give users 'hands-on' training in HydroLOGIC, preview the new CottonLOGIC prototype, and most importantly collect feedback on current and future tools. Even though participant numbers were down on previous years, the amount of feedback (over 450 responses) was successful (see Figure 13).

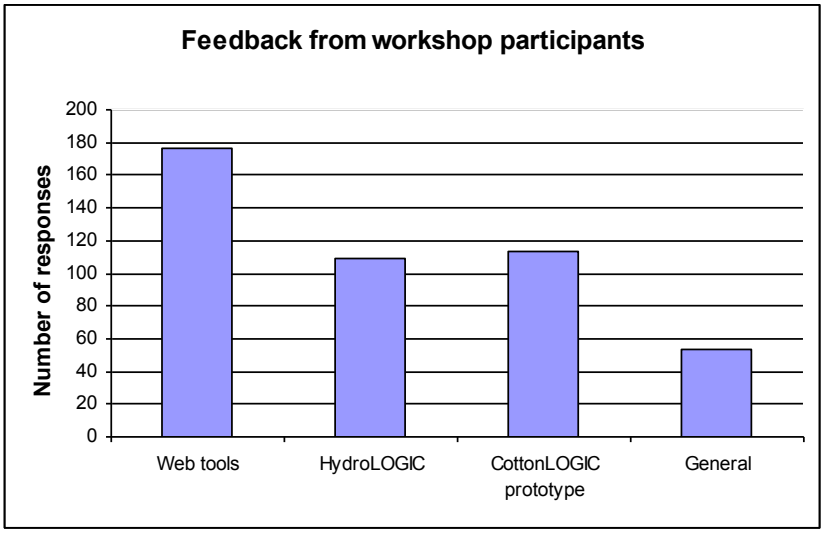

Figure 13: Number of responses relating to different decision support tools from workshop participants in Sep 2005.

Outcomes and Conclusion

Technology can assist with complex decisions that can integrate knowledge that optimise production and inputs that are sensible, profitable, and have the lowest impact on the surrounding environment. This project explicitly addressed the CRC outputs: Sustainability by empowering people with technologies that enhance the latest and best knowledge generated by latest cotton research.

The Decision Support Team was a component of the Cotton Extension Team. Regularly members of the Cotton Management Support Systems team also presented at field days and at industry conferences and forums.

Many of the tools that are now developed by the Cotton Management Support Systems team now reside on the Cotton CRC's website. Statistics on usage of these tools can be sourced easily and show that has been significant adoption (Figure 14) with a trend of increased usage over the cotton season.

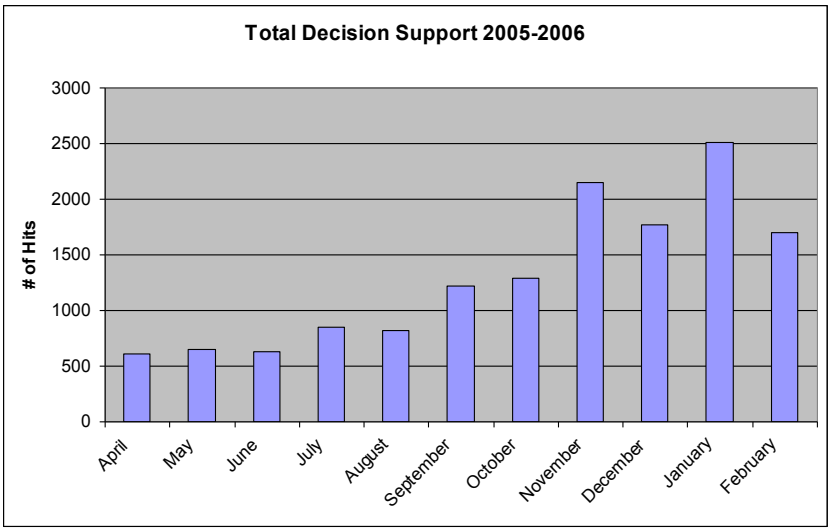

Figure 14: Summary of the number of dedicated web sessions utilising the crop development tool, cotton day-degree calculator and NutriLOGIC online

CSIRO's cotton Decision Support Software (DSS) group based in Narrabri is discontinuing because of changing research directions in response to industry requirements as recognised by the Cotton Research and Development Corporation (CRDC), combined with the lack of funding available for research as a result of the drought. As CSIRO is unable provide replacement funding, two software developers (Darren Linsley and Scott Johnston) will cease with CSIRO in June 2007 and the Cotton Management Support Systems team was disbanded from that time.

Dirk Richards and Sandra Deutscher were both experimental scientists providing linkages between research, extension and decision support. CRDC has provisionally allocated some funding for Sandra to link research, extension and BMP. Dirk was be redeployed onto another CRC-funded research project.

The main consequences as a result of these developments are that development and upgrade of existing and new decision support tools will now cease. Software tools that will be affected immediately are HydroLOGIC and the development of the new IPM tool replacing EntomoLOGIC (both desktop and handheld versions). However, the Cotton CRC and CSIRO have agreed to support one programming position (Loretta Clancy) to maintain a limited number of web decision support tools at least for one year.

The Decision Support Steering Committee will also cease to function in its present role as at the end of June 2007.

A preliminary research proposal titled 'Opportunities for Linking Research, Extension and BMP' has been submitted to both CRDC and CRC seeking support for Sandra Deutscher and Loretta Clancy. This PRP flagged potential investment by both the CRC and CRDC to improve the flow of research outcomes between research, extension and BMP and to assist in development of information tools that assist this process. This would support Sandra Deutscher, who has specialist skills with gathering and packaging research information for industry across a range of media (web, software, printed, video), and Loretta Clancy who has specialist skills with web support and development of web tools. BMP is a process to support growers in assessing their on-farm practices and to progress toward best management

standards. These standards are derived in part from research outcomes, so it is critical that there is a clear process to ensure there is a flow of research information into the BMP content. This has been an ongoing challenge for BMP. Secondly, BMP is supported by research that has been packaged in various ways to make it available to industry, often delivered via the web. Currently, there is a one year project in place which is addressing components of these needs. In one component Sandra Deutscher is to work with key industry working groups to scope opportunities and identify future investment that will improve linkages between research and BMP (CRDC supported). The other component (CRC supported) is providing funding for Loretta Clancy to maintain the CSIRO/Cotton CRC web decision support tools while a future path for these tools is established. Loretta is also providing important technical supervision needed to continue the CRC/Telstra project 'New generation scouting tools'.

Publications and Online Resources

CottonLOGIC home page
http://tools.cotton.crc.org.au/CottonLOGIC/
Crop Development Tool
http://tools.cotton.crc.org.au/CottonLOGIC/Cdt/
NutriLOGIC
http://tools.cotton.crc.org.au/CottonLOGIC/NutriLOGIC/
Water Quality Calculator
http://tools.cotton.crc.org.au/CottonLOGIC/WQC/
Diapause and Moth Emergence Calculator
http://tools.cotton.crc.org.au/cl2/diapause/index.aspx

Deutscher, S.D., Bange, M.P., Rapp, G., and Constable, G. (2007). Field tests prove value of cotton crop development tool. The Australian Cottongrower. 28(2). pp. 8-12.

Final Report Executive Summary

Project Title: Delivering Science to Agribusiness: Cotton Management Support Systems

Principal Researchers: Dr M. Bange, Ms. S Deutscher, Mr D. Linsley, Mr S. Johnston, Mr. D. Richards, Ms. L. Thakur, Ms L. Clancy

Cotton growers continue to face increasing pressure to manage resources more cost effectively and to be more accountable for the impact their decisions have on the surrounding environment. In addition to this there are significant changes in technology such as new transgenics (Bollgard II and Roundup Flex) and an increasing need to improve fibre quality and water use efficiency. There was a dedicated commitment by research organisations in the industry (CSIRO, CRDC and Cotton CRC) to develop tools and techniques for decision making from the best information available from research to help all sectors of the industry to meet crop production, social and environmental imperatives. The CSIRO Cotton Management Support Systems team based in Narrabri has evolved to meet these challenges. The team's mission is to develop, validate and deliver to the cotton industry up-to-date and scientifically grounded decision tools and extension information packages that are accepted as the benchmark for improving the profitability and sustainability of cotton production.

This two year project combined two projects previously supported by the CRDC and one by the Cotton CRC that contributed to the development of decision tools for the cotton industry. This project alone was the principle project that supported the cotton industry's investment in decision support development. Successful achievements included:

- Delivery of an operational plan for decision support development.
- Prototypes of CottonLOGIC and EntomoLOGIC were developed to meet future needs of the industry.
- HydroLOGIC was upgraded to provide greater reporting flexibility.
- NutriLOGIC was enhanced to included a greater range of nutrients and improve useability.
- A diapause and moth emergence calculator was developed.
- The Crop Development Tool was upgraded to include vegetative growth rate for assisting with growth regulant decisions. Its useability was also improved.
- A water quality calculator to estimate the impacts of water quality on crop growth was delivered.
- 'CottBASE' a database of pre-run simulations of the OZCOT model was developed.
- Members of this project team assisted in developing the technical specifications of the new Cotton Catchment Communities CRC's website.
- An industry advisory committee was facilitated.
- Training and support for the decision tools was provided.
- Web statistics showed significant adoption and use of these tools during the course of the cotton season.

As from July 2007 CSIRO's Cotton Management Support Systems team is discontinuing because of changed research directions in response to industry requirements as recognised by the Cotton Research and Development Corporation (CRDC), combined with the lack of funding available for research as a result of the drought. As CSIRO was unable to provide replacement funding, two software developers (Darren Linsley and Scott Johnston) ceased

June 2007. Dirk Richards was redeployed to another CRC project and Sandra Deutscher's position within the industry is under discussion. The main consequences as a result of these developments are that development and upgrade of existing and new decision support tools has ceased. Software tools that will be affected immediately are HydroLOGIC and the development of the new IPM tool replacing EntomoLOGIC (both desktop and handheld versions). However, the Cotton CRC and CSIRO have agreed to support one programming position (Loretta Clancy) to maintain a limited number of web decision support tools at least for one year whilst their future is resolved.

A preliminary research proposal titled 'Opportunities for Linking Research, Extension and BMP' has been submitted to both CRDC and CRC seeking support for Sandra Deutscher and Loretta Clancy. This PRP flagged potential investment by both the CRC and CRDC to improve the flow of research outcomes between research, extension and BMP and to assist in development of information tools that assist this process. This would support Sandra Deutscher, who has specialist skills with gathering and packaging research information for industry across a range of media (web, software, printed, video), and Loretta Clancy who has specialist skills with web support and development of web tools. BMP is a process to support growers in assessing their on-farm practices and to progress toward best management standards. These standards are derived in part from research outcomes, so it is critical that there is a clear process to ensure there is a flow of research information into the BMP content. This has been an ongoing challenge for BMP. Secondly, BMP is supported by research that has been packaged in various ways to make it available to industry, often delivered via the web. Currently, there is a one year project in place which is addressing components of these needs. In one component Sandra Deutscher is to work with key industry working groups to scope opportunities and identify future investment that will improve linkages between research and BMP (CRDC supported). The other component (CRC supported) is providing funding for Loretta Clancy to maintain the CSIRO/Cotton CRC web decision support tools while a future path for these tools is established. Loretta is also providing important technical supervision needed to continue the CRC/Telstra project 'New generation scouting tools'.