

REPORTS

Part 1 - Summary Details

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

CRDC Project Number: **CSP125C**

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Project Title: Continued development and field evaluation of micro-computer cotton management packages

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Research Program: Technology Transfer and Extension

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Final Report - Continued development and field evaluation of micro-computer cotton management packages

Executive Summary

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

- A handheld version of CottonLOGIC that will run on the Palm OS ® operating system for in field electronic data collection and decision-making. Many minor releases of CottonLOGIC were distributed that improved functionality of the software and fix software bugs.
- A cotton irrigation management tool HydroLOGIC was developed and released to industry for testing.
- Water budgeting software based on the research of Dr Sunil Tennakoon and Dr Stephen Milroy was made available to the industry development and water use efficiency officers.
- The CottonLOGIC database structure was documented to enable third party software to access the data contained in CottonLOGIC to be used for other purposes (e.g. GIS).
- During the course of this project the Cotton Management Support Systems team have been also responsible for the technical development of the Cotton CRC's website.
- Developed a user-friendly version of the cotton crop simulation model OZCOT.
- Various other software tools have been developed for research purposes. Some examples include software to assist in operation of experimental pickers, Fusarium assessment using the Palm handheld in the field, and tools to compile validation data for simulation model testing (e.g. compensation research).
- Two additional tools were developed as part of CottonLOGIC handheld system: GPS capability and whitefly data entry.
- Significant planning into the future infrastructure of software development to maintain and improve functionality of DSS had also commenced during the course of this project.

A brief outline of the major results and outcomes from this project are given below under the general headings of: Decision support development and distribution; Field validation of decision support; Decision support training and support; and Decision support industry feedback.

Present development in areas of DSS (e.g. CottonLOGIC), research information dissemination (e.g. Cotton CRC's website), and cotton simulation modelling (OZCOT) has been outstanding compared with the past. This has primarily occurred because of enhanced resources provided by CSIRO, the Cotton CRC, and CRDC for the employment of additional programmers over the course of the project.

A new project titled 'Delivering science to Agribusiness - novel decision support tools' that addresses current and future initiatives of information technology to assist cotton research dissemination and decision support has been funded by the Cotton CRC and CRDC.

Research Staff

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Background and Industry Significance

This project followed on from the proposal CSP98C 'Development and field testing of micro-computer cotton management packages' which aimed to support the development of CottonLOGIC and other computerised decision support systems (DSS); validate them in the field; and to provide training and support. It also complemented another project funded by the CRDC CSP106C 'Enhancing development, support and evaluation of computerised decision support' which aimed to provide additional programming and support capabilities and to evaluate the impact and nature of use of computerised decision support in the Australian Cotton Industry

Cotton growers are facing increasing pressures to manage resources more cost effectively and to be more accountable for the impact that their decisions make on the surrounding environment. Computer based decision support systems have been developed to provide cotton growers with the best information available from research to assist with their management decision making. CottonLOGIC is now available to assist growers and their advisers in pest management; crop nutrition; insect species identification; plant mapping; growth regulation; spray ordering and notification; and management of INGARD® cotton. Underlying these functions is a powerful database for storing crop management information and an end of season report generator.

At the start of this project the number of registered copies distributed to the industry had risen to over 900. CottonLOGIC had also become an industry benchmark for pest management and was recommended in the industry's Best Management Practice guidelines. In addition to this the software had gained significant recognition for its quality and usefulness by winning prestigious awards for excellence in Australian agriculture software and technology transfer in the IT industry. This proposal was to build on the success of CottonLOGIC and develop new decision tools to meet the current and future needs of the industry.

Research Proposal Summary

The nature of the aims and objectives of this project facilitated the mechanisms for industry and user feedback while remaining flexible enough to respond to the ever-changing needs of the industry. The Cotton Management Support Systems team with the CottonLOGIC software will take a leading role in allowing good science to be passed on easily and effectively to the industry.

Specifically the project aims were to:

1. Continue development and field evaluation of computerised decision support systems.
2. Promote the continued adoption of CottonLOGIC by providing training and support.
3. Facilitate mechanisms to allow industry involvement in the development of computer decision support.

Maintaining the level of resources needed to develop and deliver effective DSS is a significant challenge. The factors where resources are allocated to a task for developing decision support are summarised by the need to maintain five key elements. They include:

1. Creating innovation (developing new solutions for decision support);
2. Software development to address strategic industry issues (e.g. water and environment);
3. Industry software support (addressing day to day needs and current issues);
4. Maintaining a software development environment so that new and existing software can be developed and will function. (e.g. making sure that CottonLOGIC will run on different Microsoft windows operating systems); and
5. Developing mechanisms to gain industry feedback and input in the development of decision support.

This project followed on from an existing project mentioned above and supported the salary of Ms Sandra Deutscher (experimental scientist) and was the primary financial support for activities that encompass the five elements of decision support development mentioned above. Specific activities that utilised resources provided by this project, are summarised in Table 1.

Table 1. Roles and example activities conducted by the Cotton Management support systems team that develop cotton decision support systems.

| Team Function/Roles | Example of activities |
|-----------------------------------|---|
| Scientific foundation | Compiling and integrating knowledge for developing DSS |
| Software development | Software coding, and testing |
| Software engineering and research | Investment in maintaining software development platform, exposure to new IT systems |
| Education and training | CottonLOGIC training workshops, field days, phone support, Internet support |
| Industry Feedback | Surveys, Industry Advisory Committee |
| Packaging and Distribution | CottonLOGIC packaging (professional appearance) |
| Promotion | Attendance at trade shows, important industry events |
| Scientific Review | Attendance at conferences, publications, peer review, scientific journals |
| Field Validation | Regional specific field trials, working closely with |

| | |
|--------------------|--|
| Project Evaluation | extension Surveys, independent feedback from specialist DSS consultant |
| Administration | Personnel and project management, sourcing funding, strategic planning |

Some specific new areas of decision support that were considered for possible exploration and development in this project were:

- Area Wide Management;
- The Best Management Practice Initiative;
- Water Use Efficiency and Water Management;
- Pest Beneficials;
- Virus Spray Technologies;
- Resistance Management Strategies;
- Management of other nutrients in the soil;
- Links with weather databases via the WWW; and
- Links to other software.

Objectives to be achieved in each year of grant

Year 1

- Evaluate the hand held version of CottonLOGIC in the field.
- Facilitate an industry steering committee to provide direction and feedback on decision support systems.
- Identify, explore and develop new opportunities for computerised decision support to assist with cotton management.
- Provide support and training of computerised decision support.
- Facilitate a review of the science contained in CottonLOGIC.

Year 2

- Identify, explore and develop new opportunities for computerised decision support to assist with cotton management.

- Facilitate an industry steering committee to provide direction and feedback on decision support systems.
- Provide support and training of computerised decision support.
- Explore multi-media opportunities to assist with training and support of decision support systems.

Year 3

- Identify, explore and develop new opportunities for computerised decision support to assist with cotton management.
- Facilitate an industry steering committee to provide direction and feedback on decision support systems.
- Provide support and training of computerised decision support.
- Produce a final project report.

Summary of Outcomes

A brief outline of the major results and outcomes from this project are given below under the general headings of: Decision support development and distribution; Field validation of decision support; Decision support training and support; and Decision support industry feedback.

Decision support development and distribution

The Cotton Management Support Systems Team during the course of this project completed the following tasks:

- A handheld version of CottonLOGIC that will run on the Palm OS ® operating system for in field electronic data collection and decision-making. This software was formally release to industry at the Australian cotton conference in August 2002. We consider this a world first for this technology.
- Many minor releases of CottonLOGIC were distributed that improved functionality of the software and fixed software bugs.

- A cotton irrigation management tool HydroLOGIC was developed and released to industry for testing. The HydroLOGIC software utilises the capabilities of the OZCOT crop simulation model.
- Water budgeting software based on the research of Dr Sunil Tennakoon and Dr Stephen Milroy was made available to the industry development and water use efficiency officers. Later this functionality was included in the release of HydroLOGIC.
- The CottonLOGIC database structure was documented to enable third party software to access the data contained in CottonLOGIC to be used for other purposes (e.g. GIS).
- During the course of this project the Cotton Management Support Systems team have been also responsible for the technical development of the Cotton CRC's website. Over the course of this project the CRC's website has been upgraded to be a fully database driven website that enables improved functionality and management. Other significant improvements to the Australian Cotton CRC's website are:
 - Improved SILO day degree calculator
 - NutriLOGIC on the web.
 - Dedicated CottonLOGIC/Decision support sub-website
 - Improved search capabilities through the website.
 - Development of a Cotton CRC Staff Database
 - Web driven interface for researchers at the Australian Cotton Research Institute to enable access to weather data collected at the site.
 - Dedicated sub-website for the Cotton CRC's northern research effort.
 - Assisted in the technical development of a weed identification and information sub-web.
 - Improved ability for recent media releases/cotton tales to be loaded on the Cotton CRC's website in a more timely fashion.
- Developed a user-friendly version of the cotton crop simulation model OZCOT. All industry development officers have this tool and have been trained to use it.
- Various other software tools have been developed for research purposes. Some examples include software to assist in operation of experimental pickers, Fusarium assessment using the Palm handheld in the field, and tools to compile validation data

for simulation model testing (e.g. compensation research). It is important to note this has enabled other research activities to proceed much more efficiently.

- Collaborated with Canberra CSIRO and APSRU colleagues in implanting the common modelling protocol as well accessing a range of tools that will assist with simulation model development.
- Two additional tools were developed as part of CottonLOGIC handheld system: GPS capability and whitefly data entry.
- Sandra Deustscher has been assisting in the Facilitation of the development of the updated Pest IPM guidelines.
- Significant planning into the future infrastructure of software development to maintain and improve functionality of DSS had also commenced during the course of this project.

Present development in areas of DSS (e.g. CottonLOGIC), research information dissemination (e.g. Cotton CRC's website), and cotton simulation modelling (OZCOT) has been outstanding compared with the past. This has primarily occurred because of enhanced resources provided by CSIRO, the Cotton CRC, and CRDC for the employment of additional programmers over the course of the project.

Field validation of decision support

Validating decision support systems in real situations is important for developing effective and useful tools. Field validation of decision support during the course of this project consisted primarily of two components: finalising validation of NutriLOGIC and field validation of the handheld version of CottonLOGIC.

Ms Deustscher has also completed a draft manuscript which has been reviewed by colleagues analysing the significant amount of data collected in EntomoLOGIC field validation trials conducted over many years funded in previous projects. It is envisaged that this information will be published in refereed journals and then distributed widely across the industry.

NutriLOGIC

Large scale field trials on commercial farms have been fundamental in the validation of CottonLOGIC. A final set of NutriLOGIC trials were conducted in the 1999/2000 season. These trials have been located throughout the major cotton growing regions to validate and demonstrate the benefits of using NutriLOGIC recommendations for Nitrogen management. In summary these trials showed that with the use of NutriLOGIC significant savings in the amount of nitrogen fertiliser could be attained without losses in yield. It also highlighted significant limitations in the use of petiole sampling for the use in nitrogen fertiliser management. Ms Deutscher has published some these results in industry publications and is currently processing all information for publication in a refereed scientific journal. The collated information will then be used to promote the use of NutriLOGIC for nitrogen fertiliser management across the industry.

CottonLOGIC for Palm OS handhelds

To evaluate a system such as the handheld version of CottonLOGIC, it was important to involve the end users such as consultants and agronomists. Scientific colleagues in Kununurra and Katherine in northern Australia evaluated the first version of the handheld followed by a pilot test group formed across the industry. The pilot group consists of 4 agronomists, 3 consultants and 1 grower. The system was tested in a group which varied in terms of the size of the enterprises and they way they endeavoured to use the software. Using this pilot group rigorous in-field validation and project evaluation activities were carried out over a period of 18 months prior to release. The majority of ideas and concepts generated from this field validation were implemented for the formal release.

In addition to large-scale field evaluation, smaller trials were also conducted to address specific concerns. For example, a major benefit of using CottonLOGIC for the Palm OS® was thought to be its time saving ability. To confirm the potential time saving advantage, small time trials were conducted. The time taken by users was measured entering the same insect data into the handheld and then on the insect checking cards using a pencil. Time was also measured entering the insect data from the cards into CottonLOGIC on a desktop computer, compared with downloading automatically to the desktop with the handheld system. The results showed that on average, the time taken to enter insect data into the

handheld was considerably more than the paper (card) system, although this depended on the level of skill of the person using the handheld. A skilled Palm handheld user could enter data as quickly as the traditional method. On average the time taken to synchronise the palm to the desktop was 45% less than the time taken to enter data from the cards into the desktop. The added benefit was that during this time other activities could be undertaken.

Another major concern was the durability of using the handheld devices in the field, particularly when the field was wet. To alleviate these concerns, a plastic water-resistant pouch was sourced that protected the device, and made it easier to carry and use.

In addition to in-field validation, the services of an independent consultant were employed to assess the value of the technology in assisting with cotton management decisions (Van Beek, 2002). The general expectation captured prior to the use of CottonLOGIC for Palm OS handhelds, mentioned by all interviewees, was that it would save time with data entry. Other expectations were that it would provide better quality data with fewer mistakes, provide a set format for data collection, and add value to the service that a consultant could provide. Following the season where the majority of the users had persisted in using the software, the evaluation showed that most had believed that it had met their expectations, and believed with improvements in some areas, the product would be successful. Some of the comments made by people who had used the system were:

‘The Palm-top is only new and of course there are hick-ups and extra things we want. But it improves our lifestyle as much as it improves our business’

An interviewee said that using the handheld ‘had not affected decisions much this year but it will make them quicker next year, less guesstimating and sorting manually through files. It is quicker especially on the CottonLOGIC side for forecasting insect populations, and that will give better decisions. It will definitely be an improvement. And it gives more confidence’.

‘You get the info in your pocket, the history, and you become able to make decisions in the field, and get the application quickly, rather than have to go home and go look for the info. It speeds up the process and that is important especially in sensitive areas.’

The concepts and ideas expressed from these evaluations set the foundation for promoting and developing future developments of CottonLOGIC for the Palm OS handheld.

Decision support training and support

With over 1090 registered copies of CottonLOGIC now within the industry, and with growers realising the necessity to exercise best management practices, the number of people who require CottonLOGIC training has remained very high. Each year of this project the Cotton Management Support Systems group conducted dedicated workshops for CottonLOGIC software in each of the major cotton growing regions.

In September 2000 there were a total of seventeen workshops held from Emerald in QLD to Hillston in NSW. The new areas covered were Murgon and Condobolin. A total of 250 participants attended these workshops, which were similar figures to the 1999 workshops.

Eleven CottonLOGIC training workshops were held during 2001 from Emerald to Hillston. Over 100 new and existing users attended the workshops. With very few major changes in CottonLOGIC in this year the main aim was to train new users and for the CottonLOGIC team to come up to speed with local and regional issues.

In September 2002 a total of 14 workshops were again conducted from Emerald to Hillston. Over 100 participants attended these workshops. These workshops focussed on training users in the use of CottonLOGIC for Palm OS handhelds.

During the course of the project Sandra Deutscher also conducted a CottonLOGIC workshop in Darwin for the researchers involved in the Northern Australia program of the Cotton CRC. At the completion of each of these workshops participants were given the opportunity to comment on the conduct and content of the workshops. Feedback showed that the workshops style and format were appropriate. Suggestions on other training in decision support were also ascertained.

We have also been working with more Universities and colleges (Warren TAFE, UQ, UNE, Emerald Ag, and Sydney University) to enable CottonLOGIC to be included in their courses. Currently CottonLOGIC is been used in the Cotton CRC's cotton production course, plant

protection at The University of Queensland, and the cotton production certificate through Warren TAFE.

In addition to the training the Cotton Management Support Systems has maintained a phone help desk available approximately 3 days per week through the Cotton CRC's Technology resource centre.

Decision support industry feedback

Constructive feedback is imperative for the development of useful decision support systems. The Cotton Management Support Systems uses the following mechanisms to assist in feedback from the industry:

- Facilitating an industry advisory committee for decision support;
- A dedicated CottonLOGIC/decision support website;
- CottonLOGIC training workshops;
- A dedicated phone help desk through the Cotton CRC's Technology Resource Centre;
- Attendance at industry conferences and forums;
- Evaluation using an independent consultant;
- On-farm field validation of decision support systems ;
- Involvement in the Cotton CRC's extension network; and
- Formal surveys.

The decision support advisory committee was formed in July 1999 to play an important role in assisting the development of decision support tools such as CottonLOGIC. The committee is made up of a range of stakeholder representatives, to ensure that the industry has direct contribution to the development of decision support.

During the course of this project three committee meetings were held. The first in July 2000, focused on providing crucial input needed for the development of the CottonLOGIC handheld system. The second meeting held in early 2002 discussed the re-engineering of CottonLOGIC and other software to meet the future needs of the industry, demonstration of water management software HydroLOGIC, and demonstration of CottonLOGIC handheld.

The third meeting specifically reviewed the IPM elements of CottonLOGIC. Many ideas and opportunities for the Cotton Management Support Systems team were identified.

In April 2001 a 'science into software' workshop was facilitated by members of the Cotton Management Support Systems team to discuss ways of improving the science in CottonLOGIC, as well as discussing means of ensuring new science is incorporated. Standard procedures were identified as well as highlighting the science in CottonLOGIC that needs reviewing by the scientists specialising in the particular areas. Dr Bange has constructed a working document outlining some processes that may be put in place to address the issue of maintaining the science component of CottonLOGIC.

How has your research addressed the Corporations three outputs: Sustainability, profitability and international competitiveness, and/or people and community?

Providing cotton managers with the latest research via CottonLOGIC and other decision tools, enables decisions to be made that are sensible, profitable, and have the lowest impact on the surrounding environment. CottonLOGIC has become an industry standard in record keeping and pest management, and thus its use is recommended in the Best Management Practice guidelines. This project has also been integral in enabling the redevelopment of the decision support system HydroLOGIC which has been released to assist with increasing yields and improve water use efficiency of irrigated cotton crops.

Dissemination of the Project Outcomes

Development of DSS is specifically aimed at research dissemination. CottonLOGIC and other decision support software are continually being released or upgraded via the Cotton CRC's website or distributed through the Cotton CRC's Technology Resource Centre. This project also has strong links with the operation of the Technology Resource Centre of the Cotton CRC and delivery of research outcomes from both CRDC and Cotton CRC funded projects.

Software is provided free to industry.

Publications arising from this research project

Journal Papers

- Bange, M.P., Deutscher, S.D., Larsen, D., Linsley, D., and Whiteside, S. (2003). Handheld decision support system facilitates improved insect pest management in Australian cotton systems. Accepted Computers and Electronics in Agriculture.
- Hearn, A.B. and Bange, M.P. (2002). SIRATAC and CottonLOGIC: persevering with DSSs in the Australian Cotton Industry. *Agricultural Systems*. 74 (1) pp. 27-56.

Conference papers

- 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. The Aust. Cotton Growers Research Organisation, pp. 629-637.
- Deutscher, S.D., Bange, M.P., Johnston, S., Larsen, D., Linsley, D., and Whiteside, S. (2002). Introducing CottonLOGIC for the Palm OS® handhelds. In Proc. 11th Aust. Cotton Conf. 13-15 August, Brisbane Aust. The Aust. Cotton Growers Research Organisation, pp. 831-835.
- Deutscher, S.D., and Bange, M.P. (2003). Advancements in computerised decision support for Australian cotton systems. In Proc. 3rd World Cotton Conf. Capetown, South Africa.
- Deutscher, S.D., 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. www.regional.org.au/au/asa/2001/3/c/deutscher.htm
- Deutscher, S.A. (2000). Validation and Calibration of NutriLOGIC. In Proc. 10th Aust. Cotton Conf. 16-18 August, Brisbane Aust. The Aust. Cotton Growers Research Organisation, pp. 315- 319.

Conference Abstract

- Bange, M.P. (2003). Building and Maintaining the Bridge: From Research to Technology Transfer. In Proc. Integrated Biological Systems Conference. 14-16 April, San Antonio, Texas, USA. Biological Systems Simulation Group. pp. 28-29.

Grower magazines and articles

- Bange, M.P. (2002). Palm-off cotton pests with new computer tool. 131. *Farming Ahead*.

- Deutscher, S.A. (2001). Supporting science through CottonLOGIC. Australian Cotton Grower magazine. Nov/ Dec issue 2001.
- Deutscher, S.A. (2001). NutriLOGIC Trial Results 1999/2001 (Boggabri) Upper Namoi Valley Cotton Trials Booklet.
- Deutscher, S.A. (2002). NutriLOGIC – optimising your N fertiliser rates. Proceedings of Lower Namoi Field Day.
- McKinnon, C., Deutscher, S. A., Dillon, M., Mansfield, S. and Staines, T. (2003) Comparison of the beat sheet technique with established methods for sampling pest and predator abundance in cotton. Lower Namoi Field day booklet Feb 2003.
- Deutscher, S.D., Bange, M.P., Johnston, S., Larsen, D., Linsley, D., and Whiteside, S. (2002). Handheld decision support takes science to the field. 23(4). The Australian Cottongrower pp.18-20.
- Deutscher, S.D., and Bange, M.P. (2003). Cotton decision support – What does the future hold? The Australian Cottongrower. 24(4). pp. 6-8.

Presentations and public relations

Conference presentations

- Bange, M.P. (2003). Building and Maintaining the Bridge: From Research to Technology Transfer. In Proc. Integrated Biological Systems Conference. 14-16 April, San Antonio, Texas, USA. Biological Systems Simulation Group.
- Bange, M.P. (2000). Crop models and decision support – Future developments and applications. 10th Aust. Cotton Conf. 16-18 August, Brisbane Aust. The Aust. Cotton Growers Research Organisation.
- Bange, M.P. (2002) Cotton Decision Support Systems and OZCOT Development. Cotton Consultants Australia Annual Meeting Narrabri.
- Deutscher, S.D. (2000) Useful Internet Sites. 10th Aust. Cotton Conference, 16-18 August, Brisbane Aust. Women in Agriculture session.
- Deutscher, S.D. (2001). Testing NutriLOGIC, a decision aid for nitrogen fertiliser management in cotton. 10th Australian Agronomy Conference, Hobart, TAS. 2001.

Promotional Activities

- Promotion of CottonLOGIC at the 2000, 2001, and 2002 Moree trade shows.
- CottonLOGIC was promoted at the Macquarie food and fibre festival 2001.

Promotion of CottonLOGIC at the August 2000 and 2002 Australian Cotton Conference, Brisbane.

Cotton research and CottonLOGIC was promoted at the 75th anniversary celebrations of CSIRO at Black Mountain Canberra (2002).

Media interviews

Michael Bange interviewed by radio 2WEB on the application and success of CottonLOGIC (2001).

Michael Bange was interviewed by Diamond Media following the formal release of CottonLOGIC for the Palm OS handhelds (2002).

Michael Bange was interviewed by the ABC Country Hour following the formal release of CottonLOGIC for the Palm OS handhelds (2002).

Michael Bange interviewed by radio 2VM on the release of the Palm OS handheld version of CottonLOGIC (2002).

Awards

CottonLOGIC for Palm OS handhelds won the Natural Resource category of the Australian component of the Asia Pacific Information and Communication Technology Awards (2002).

CottonLOGIC for Palm OS handhelds was a finalist in the Australian Museum Eureka Science Awards for IT innovation (2003).

Other

Michael Bange prepared a discussion paper for the ACGRA and CRDC on present issues impacting on development and delivery of decision support and OZCOT (2002). (Appendix 1)

Project Impact and Evaluation

The Australian Cotton Industry has a strong reputation for accepting and adopting innovative computerised DSS to improve crop and pest management and have benefited from doing so (Hearn and Bange, 2002). A recent independent assessment of the cost benefits of the pest

management component of CottonLOGIC adopted in the Australian cotton industry found a benefit:cost ratio of 18.5 (The Centre for International Economics, 2003). The demand for reliance on this technology is also increasing. The number of registered CottonLOGIC users has steadily increased from 200 in 1995 to over 1100 presently (Fig. 1). In addition, a recent survey (August 2002) showed that CottonLOGIC had been used across 51% (207 208 ha) of the total area of cotton grown in Australia in the 2001/2002 cotton season (404 000 ha; Dowling, 2002). Of this area where CottonLOGIC was used, 93% of use was for record keeping (insect and operational data) elements of the software, while 69% was to assist with management decisions using research models embedded in CottonLOGIC (Table 2).

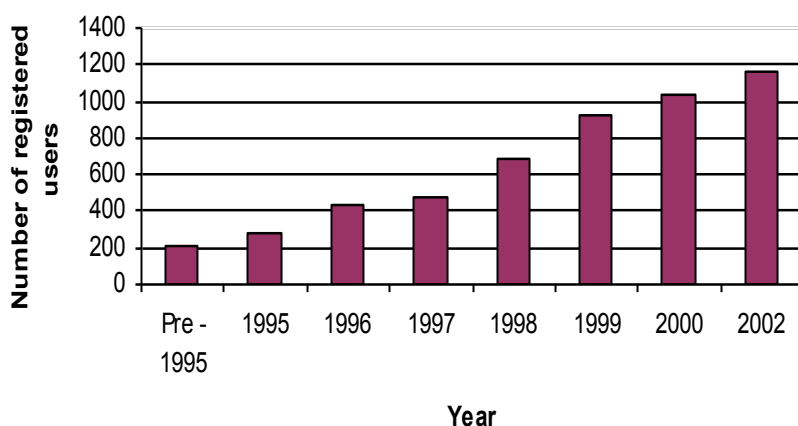


Figure 1: Increase in registered copies of *CottonLOGIC* distributed to the Australian cotton industry.

Table 2: Results of a survey measuring *CottonLOGIC* use (in area) in the Australian cotton industry (August 2002; 135 survey respondents).

| CottonLOGIC Function | Area Used (ha) | Proportion of total |
|--|----------------|---------------------|
| Insect identification tool | 84811 | 41 |
| Record keeping capabilities | 193348 | 93 |
| <i>Helicoverpa</i> spp. prediction model | 63452 | 31 |
| Two spotted spider mite model | 39210 | 19 |
| NutriLOGIC – Nitrogen model | 21950 | 11 |
| Spray ordering capabilities | 33756 | 16 |
| Decision Support (excluding record keeping and spray ordering) | 142072 | 69 |
| <i>Total Area of Cotton Industry</i> [†] | 404000 | |

[†] Source Dowling (2002)

In addition to the information collected above some independent evaluation activities were conducted by Peter Van Beek, a consultant specialising in the evaluation of decision support. Results of his findings collected during the course this project are presented in the final report for the CRDC project CSP106C ‘Enhancing development, support and evaluation of computerised decision support’.

Future Research Needs

The focus of the Cotton Management Support Systems Team is to take a leading role in ensuring that good science to be passed on easily and effectively on to the industry. 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.

Advances in information technology through improvements in desktop software, handheld devices and the Internet have provided significant opportunities to enhance the development of DSS. Current and ongoing developments of DSS aim to utilise and integrate these technologies to improve cotton management with research outcomes. Some of these initiatives are:

- HydroLOGIC. A cotton irrigation scheduling and management tool, which allows users to explore the consequences of irrigation management on cotton development, yield and water use.
- Crop compensation. Incorporating knowledge of the ability of cotton crops to compensate for pest damage into DSS.
- Area wide management. Improving the ability of farmers and advisers to share knowledge to address regional issues relating to pest management.
- Farm water accounting. Providing irrigated cotton growers with software to track the movement of the water resource on their farm and calculate efficiencies (e.g. irrigation efficiency).
- HEAPS. Exploit the capabilities of the HEAPS (Helicoverpa Armigera and Punctigera Simulation) model, which simulates *Helicoverpa* spp. population growth

and dispersal over a region, to specifically support resistance management for transgenic cotton and conventional insecticides.

- 3rd Party software integration. Improve the ability of the CottonLOGIC software to share information with other software.
- Improved information delivery. Engage the use of multi-format software tools that allow rapid publication of Web, hardcopy and CD based information. This initiative has the ability to make information widely available, easier to access, navigate and upgrade, and more cost effective as information changes.

A new project titled ‘Delivering science to Agribusiness - novel decision support tools’ has been supported by both the Cotton CRC and the CRDC to address the issues presented above.

The aims of the project are:

1. To interact with researchers, extension personnel and industry to identify critical issues where decision support tools can help growers.
2. To 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. To provide support for researchers and to facilitate industry involvement in the development of computer decision support.
4. To maintain and support existing software packages to ensure their ongoing development, relevance and performance.

Present major issues facing DSS development are as follows:

- A critical link needed to drive the future of DSS is to have resources that canvas the research being undertaken, and further develop this research into a form that can be used for assisting with crop management decisions.
- Software, support is a crucial factor in its adoption and success. While the cotton management support systems group endeavours to provide this as best as possible, it is difficult to maintain at a high level because of the resources required.
- IPM in CottonLOGIC is lacking. Resources will be required to help develop any initiatives needed for implementation into DSS. This includes area wide management.

- Presently our present DSS products (especially CottonLOGIC) have been developed in an environment, which is no longer supported within present computer operating systems and may not function in the near future.
- Considerable resources for the next two years, without any direct visible outcomes are needed to prevent this situation. Will need support from the industry before committing.
- There has been general agreement within the Cotton CRC that the role of its website is to deliver research information.
- As with any research program maintaining funding is important. A situation arises when there are many projects funding a similar initiative. It becomes very difficult to get new initiatives started when there is pressure to maintain existing ones.

It is envisaged that that in consultation with the CSIRO Cotton Research Unit's Cotton Management Support Systems Team a business plan supported by the CRDC and the Cotton CRC will be developed. A discussion paper presented to the ACGRA and CRDC that discusses these issues in more detail is attached (Appendix 1).

Final Report Summary - Continued development and field evaluation of micro-computer cotton management packages

Principal Researchers: Dr Michael Bange Research, Ms Sandra Deutscher, Mr Scott Johnston, Mr Darren Linsley, Mr Stewart Whiteside, Mr Dirk Richards (CSIRO Plant Industry Cotton Research Unit), and Mr David Larsen (New South Wales Agriculture).

Project Aims:

1. Continue development and field evaluation of computerised decision support systems.
2. Promote the continued adoption of CottonLOGIC by providing training and support.
3. Facilitate mechanisms to allow industry involvement in the development of computer decision support.

Summary:

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

- A handheld version of CottonLOGIC that will run on the Palm OS ® operating system for in field electronic data collection and decision-making. Many minor releases of CottonLOGIC were distributed that improved functionality of the software and fix software bugs.
- A cotton irrigation management tool HydroLOGIC was developed and released to industry for testing.
- Water budgeting software based on the research of Dr Sunil Tennakoon and Dr Stephen Milroy was made available to the industry development and water use efficiency officers.
- The CottonLOGIC database structure was documented to enable third party software to access the data contained in CottonLOGIC to be used for other purposes (e.g. GIS).
- During the course of this project the Cotton Management Support Systems team have been also responsible for the technical development of the Cotton CRC's website.
- Developed a user-friendly version of the cotton crop simulation model OZCOT.
- Various other software tools have been developed for research purposes. Some examples include software to assist in operation of experimental pickers, Fusarium assessment using the Palm handheld in the field, and tools to compile validation data for simulation model testing (e.g. compensation research).
- Two additional tools were developed as part of CottonLOGIC handheld system: GPS capability and whitefly data entry.
- Significant planning into the future infrastructure of software development to maintain and improve functionality of DSS had also commenced during the course of this project.

Present development in areas of DSS (e.g. CottonLOGIC), research information dissemination (e.g. Cotton CRC's website), and cotton simulation modelling (OZCOT) has been outstanding compared with the past. This has primarily occurred because of enhanced resources provided by CSIRO, the Cotton CRC, and CRDC for the employment of additional programmers over the course of the project.

Field Validation of DSS - Validating decision support systems in real situations is important for developing effective and useful tools. Field validation of decision support during the course of this project consisted primarily of two components, finalising validation of NutriLOGIC and field validation of the handheld version of CottonLOGIC.

DSS training and support - With over 1090 registered copies of CottonLOGIC now within the industry, and with growers realising the necessity to exercise best management practices, the number of people who require CottonLOGIC training has remained very high. Each year of this project the Cotton Management Support Systems group conducted dedicated workshops for CottonLOGIC software in each of the major cotton growing regions.

Decision support industry feedback - Constructive feedback is imperative for the development of useful decision support systems. The Cotton Management Support Systems uses the following mechanisms to assist in feedback from the industry: Facilitating an industry advisory committee for decision support; a dedicated CottonLOGIC/decision support website; CottonLOGIC training workshops; A dedicated phone help desk through the Cotton CRC's Technology Resource Centre; Attendance at industry conferences and forums; Evaluation using an independent consultant; On-farm field validation of decision support systems; Involvement in the Cotton CRC's extension network; and Formal surveys.

A new project titled 'Delivering science to Agribusiness - novel decision support tools' that addresses current and future initiatives of information technology to assist cotton research dissemination and decision support has been funded by the Cotton CRC and CRDC.

Appendix 1 Discussion Paper on Decision Support Issues

Cotton Decision Support Systems and OZCOT Development

Dr Michael Bange CSIRO/Cotton CRC Mar 2002

Summary

The purpose of this discussion paper is to update ACGRA on the present issues relating to cotton decision support development (DSS) and OZCOT. The issues presented and discussed more fully are:

1. *Development of Cotton Decision Support Systems (DSS)*
 - In general terms decision support systems discussed in this paper are computer-based systems to aid crop management decisions.
 - We do not only develop CottonLOGIC, but also develop tools that aim to assist research and information transfer.
 - DSS direction comes about by recognising the needs of the groups that represent both the Australian Public and the cotton industry.
 - Successful development and delivery of decision support encompasses many different processes from the conception of an idea through to delivery and support.
2. *Current resourcing of DSS development*
 - Currently, funding for cotton decision support development comes from three different sources, CSIRO appropriation, CRDC, and the Australian Cotton CRC. CSIRO provides the majority of funding.
 - Industry input is critical to research and development, and the emphasis is to work alongside with industry to achieve progress.
 - Resource allocation based on a need to maintain four key elements. They include: Creating innovation; Strategic Software development; Industry software support; and maintaining a useful software development environment.
 - An extremely important lesson that has been learnt from developing DSS or any software for that matter is not to let one of these elements dominate.
3. *Progress of DSS and OZCOT development*
 - Present development in both areas DSS and OZCOT has been outstanding compared with the past.
 - This has primarily occurred because of enhanced resources provided by CSIRO, and the CRDC for the employment of additional programmers over the last three years.
 - A list of major developments are included in paper.
4. *Present major issues facing DSS development*
 - A critical link needed to drive the future of DSS is to have resources that canvas the research being undertaken, and further develop this research into a form that can be used for assisting with crop management decisions.
 - Software, support is a crucial factor in its adoption and success. While the cotton management support systems group endeavours to provide this as best as possible, it is difficult to maintain at a high level because of the resources required.
 - IPM in CottonLOGIC is lacking. Resources will be required to help develop any initiatives needed for implementation into DSS. This includes area wide management.
 - Presently our present DSS products (especially CottonLOGIC) have been developed in an environment, which is no longer supported within present computer operating systems and may not function in the near future.
 - Considerable resources for the next two years, without any direct visible outcomes are needed to prevent this situation. Will need support from the industry before committing.
 - There has been general agreement within the Cotton CRC that the role of its website is to deliver research information.

- As with any research program maintaining funding is important. A situation arises when there are many projects funding a similar initiative. It becomes very difficult to get new initiatives started when there is pressure to maintain existing ones.

Development of Cotton Decision Support Systems

Definition of Cotton Decision Support Systems

In general terms decision support systems discussed in this paper are computer-based systems to aid crop management decisions. A primary aim of the decision support and modelling teams in the cotton industry is to utilise sound and up to date research and technology, and integrate this technology across different electronic platforms and mechanisms, and finally delivering it to the industry for adoption, ‘Science into Practice’.

The ‘Cotton Management Support Systems’ group based at Narrabri leads the CSIRO Cotton Research Unit’s effort into DSS. An important point to note is that this group develops a range of computer tools, which come under the definition of computerised DSS (Fig. 1). We do not only develop CottonLOGIC, but also develop tools that aim to assist research and information transfer.

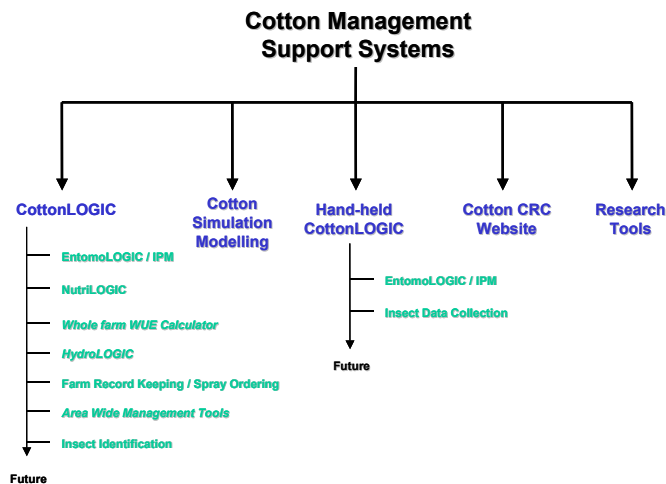


Figure 1: Cotton management support systems developed by CRU (Italicised products are under development).

Who are we developing decision support for?

The Cotton Management Support Systems team at Narrabri believe their primary role is to serve the Australian Public through provision of technology that assists in maintaining a sustainable cotton industry that is both economically and environmentally viable. This direction comes about by recognising the needs of the groups that represent both the Australian Public and the cotton industry. The groups we directly operate with are:

- The Australian cotton grower;
- The cotton consultant (they help cotton growers);

- CSIRO's scientists to further enhance their work;
- The Cotton Research and Development Corporation; and
- The Australian Cotton Cooperative Research Centre.

What is required to develop decision support?

Another important aspect when considering the process of development of computerised decision support is that does not only include the programming of the software. Successful development and delivery of decision support for adoption by industry encompasses many different processes from the conception of an idea through to delivery and support. Some of the important defined functions and activities of the decision support team presently undertaken are outlined in Table 1. Each role requires resources and is critical to the overall success of the products delivered by the team.

Table 1: Team functions and examples of activities of the decision support team.

| Team Function | Example of activities |
|-----------------------------------|---|
| Software development | - Software coding, and testing |
| Software engineering | - Investment in maintaining software development platform |
| Education and training | - CottonLOGIC workshops, field days |
| Support | - Phone support at the Cotton CRC's Technology Resource Centre (TRC), direct support |
| Industry Feedback | - Workshops, TRC, Industry Steering Committee |
| Packaging and Distribution | - CottonLOGIC packages, and mail outs through the TRC |
| Promotion | - Attendance at trade shows, local shows with the TRC |
| Scientific Review | - Attendance at Scientific Conferences, Publications, Peer Review, Scientific Journals |
| Field Validation | - Regional specific field trials using CottonLOGIC, working closely with the Industry Development Officers |
| Project Evaluation | - Surveys, Independent feedback from specialist DSS Consultant |
| Administration | Personnel and project management, sourcing funding, strategic planning |

In an endeavour to achieve a focus on developing and delivering decision support, it is important to define a consistent and equitable strategy based on simple philosophical and moral principles to meet the needs of all stakeholders relevant to the cotton industry, and to the development of decision support. Points which try to encompass the philosophy by which the decision support team attempts to function are as follows:

1. Aim to develop effective, useful and user-friendly computerised decision support systems backed by good science.
2. Promote responsible crop management based on the best and most appropriate science that is accepted by industry (e.g. Best Management Practice).
3. Responsibility for the science used in the software is inherently shared by all researchers involved, and not entirely by developers of decision support.
4. Selection of priority areas for effort is based on appropriate constructive feedback and industry input.
5. No group or region within the industry will be favoured nor ignored.
6. Approach each task pragmatically, and only after careful planning and responsible considerations commit to software development.

7. Make activities and decisions transparent to superiors, industry and funding bodies.
8. Produce quality outcomes, thoroughly tried and tested.
9. Decision support systems are just that, they do not make the decisions, but provide information to assist in the decision-making processes. Promote the decision support systems as tools. (E.g. Promote IPM, and CottonLOGIC helps achieve this)

Current Resourcing of DSS Development

Who funds DSS projects?

Currently, funding for cotton decision support development comes from three different sources, CSIRO appropriation, CRDC, and the Australian Cotton CRC. CSIRO provides the majority of funding from appropriation; while Cotton CRC funds are federal monies provided to research, separate from grower levies. The relative proportion of funding is represented in Figure 2. Industry input is critical to research and development, and the emphasis is to work alongside with industry to achieve progress. CSIRO also commits funds to research where industry provides contribution to development.

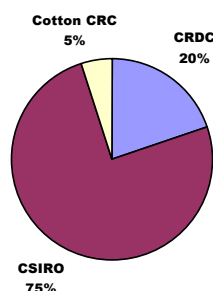


Figure 2. Relative proportion of funding from respective sources for cotton research and development in DSS and OZCOT.

What projects do we have who do they support and what is their purpose?

Current projects funded by the CRDC for DSS (including OZCOT) are:

- Enhancing Development, Support and Evaluation of Computerised Decision Support – This project provides funding for employment of one programmer (Darren Linsley), provision of services of an independent consultant for DSS evaluation, and a small amount of operating.
- Continued development and field evaluation of micro-computer cotton management packages – This project provides funding for employment of Sandra Deutscher who's role is to conduct field validation of DSS, training and some support. The project also provides some operating, and funding for the duplication of software and costs for distribution.
- Application of crop simulation within the Australian Cotton Industry – This project provides funding for the employment of Mr Dirk Richards who is researching the application of the crop simulation model OZCOT in assisting crop management as well as collaborating with other projects, which use the model as a tool in research.

Current project funded by the Cotton CRC is:

- Developing innovative computer based technologies for effective delivery of information and cotton management decision support – This project supports one programmer (Stewart Whiteside) whose role is to support development of the Cotton CRC's website and the development of the Handheld CottonLOGIC.

It is important to note that the project 'ACRI Computer Network Support' is not a defined as a decision support project. This project supports all research at ACRI in providing continuous and reliable access to computing services to all staff. Dr Michael Bange is the supervisor of the Tony Pfeiffer who undertakes this key role.

Who are the people and what are their roles?

Dr Michael Bange – CSIRO Senior Research Scientist (Project Leader) - CSIRO funded
 Mr Darren Linsely – CSIRO Software Developer (CottonLOGIC) – CRDC funded
 Mr Scott Johnson – CSIRO Software Developer (Water Management Tools) – CSIRO funded
 Mr Stewart Whiteside – CSIRO Software Developer (Web based tools and software engineering issues) – Cotton CRC funded
 Mr David Johnson – CSIRO Programmer (Cotton Crop Simulation Model OZCOT) – CSIRO funded
 Mr Dirk Richards – CSIRO Experimental Scientist (Application of cotton simulation model and HydroLOGIC) – CRDC funded
 Sandra Deutscher - CSIRO Experimental Scientist (CottonLOGIC evaluation and field validation, support and training, Agronomist) – CRDC funded
 David Larsen (NSW Agriculture, Coordinator Australian Cotton CRC's Technology Resource Centre) – Cotton CRC funded

How are resources allocated?

Along with time and resources needed to maintain those tasks described in Table 1. There are other factors that determine how resources are allocated to a task. Simply the decision to undertake a task and thus allocate resources is based in the need to maintain four key elements. They include:

- Creating innovation (developing new solutions);
- Software development to address strategic industry issues (e.g. water and HydroLOGIC);
- Industry software support (addressing day to day needs and current issues); and
- Maintaining a software development environment so that new and existing software can be developed and will function. (e.g. making sure that CottonLOGIC will run on different MS windows platforms).

An extremely important lesson that has been learnt from developing DSS or any software for that matter is not to let one of these elements dominate. They must be considered equally for the success and future of the significant investment in DSS. To allow one to dominate is at the expense of another, but ultimately resources are needed to bring the other elements in line. The quandary is that in doing this other elements again suffer.

Progress of OZCOT and DSS development

Present development in both areas DSS and OZCOT has been outstanding compared with the past. *This has primarily occurred because of enhanced resources provided by CSIRO, and the CRDC for the employment of additional programmers over the last three years.*

In the case of computerised decision support systems in the past two years we have been able to complete:

- A handheld version of CottonLOGIC that will run on the Palm OS ® operating system for in field electronic data collection and decision-making. This is currently being tested with a large group throughout the industry before the release at the next ACGRA cotton conference. We consider this a world first for this technology.
- A prototype whole farm and field water accounting package and water use efficiency calculator. The water use efficiency officers in Queensland and New South Wales are presently testing this. To be included in CottonLOGIC.
- Redevelopment of a functional and visually improved Cotton CRC website. Deployed early Dec 2001.
- Dedicated resources to the redevelopment of cotton crop simulation model OZCOT. The model is pivotal in the research effort into farming systems, HydroLOGIC, compensation and fibre quality.
- Publication of specifications to allow other programmers to develop software that can communicate and access CottonLOGIC information.
- Development of a Beta version of HydroLOGIC (Irrigation scheduling and management) for preliminary testing this summer. To be included in CottonLOGIC.
- Resources to work with SILO to improve Cotton Industry's access to weather data through the Internet and CottonLOGIC software.
- Development of a user-friendly version of OZCOT. All industry development officers have this tool and have been trained to use it.
- We have also managed to maintain general support for CottonLOGIC. Fixing bugs and some improvements in reporting capabilities.
- Enhanced training in the use of CottonLOGIC. We are working with more Universities and colleges (Warren TAFE, UQ, UNE, Emerald Ag) to enable CottonLOGIC to be included in their courses.
- Compiling and publishing the results of validation experiments conducted over the past 10 years for promoting CottonLOGIC, IPM and nitrogen management.
- Various other software tools developed for research purposes. Some include software to present weather data on the Internet, software to assist in operation of experimental pickers, Fusarium assessment using the Palm handheld in the field, tools to compile validation data for simulation model testing. *Important to note this has enabled other research to proceed much more efficiently.*
- Significant planning into the future infrastructure of software development to maintain and improve functionality of DSS.

Present major issues facing DSS development

Generating Innovation

An extremely critical link needed to drive the future of DSS is to have resources to canvas the research being undertaken by other researchers and further develop this research into a form that can be used for assisting with crop management decisions. In this case inclusion into computerised decision support. Essentially the person who would undertake this responsibility would be a farming 'systems' scientist with their focus on meeting the needs of decision support. This position is the link between the fundamental research and the development of the software.

An important aspect of this link is that the technology being developed or assessed has a scientific basis on which to draw, as well as being able to withstand scientific scrutiny. For example, when a methodology to monitor crop 'cutout' is developed it should be substantiated with appropriate understanding of crop physiology and crop agronomy.

Some of the key areas in which the scientist could undertake research are:

- Integration of sampling and crop monitoring methodologies to meet the needs of IPM and other crop management decisions (e.g. growth regulators, irrigation and crop defoliation).
Assess the relevance of current pest management methodologies and compare new technology for inclusion in decision support.
Assess the relevance of American crop monitoring techniques and establish the relevance to the Australian Cotton Industry. It is also important to substantiate the scientific basis of the methodology for Australian farming systems and cotton cultivars.
- Integrating the science of different water management tools and establishing simple methodologies to meet the needs of growers for the use of these tools

Presently the efforts of the Cotton Research Unit from this perspective in this area are limited. The cotton management support team are working on ways to enhance this area, but at some stage may require industry support for this type of role, if present initiatives put forward do not succeed.

Enhancing Software Support

With all software, support is a crucial factor in its adoption and success. While the cotton management support systems group endeavours to provide this as best as possible, it is difficult to maintain at a high level because of the resources required. When time is devoted to support, resources are taken away from development. To add to this, software support has traditionally not been defined as a role of the organisations that employ the members of the cotton management support systems team.

One proposal that has been put forward is to obtain resources specifically to meet the day-to-day programming needs of the industry provided through a support desk based at Narrabri. These resources would essentially be independent to software development.

Software Support is an issue that the ACCGRA may be able to discuss in context of the other needs of the industry.

Progressing/Protecting the Investment in DSS

An important element that needs to be considered in the development of DSS is that software development itself comes with a certain level of overhead. Essentially with a group as large as we are, we need to develop procedures and protocols, so that software is developed effectively. We have suffered from not doing this properly in the past and are now paying the price.

Presently we are faced with a situation where our present DSS products (especially CottonLOGIC) have been developed in an environment, which is no longer supported within present computer operating systems. This poses two major problems:

- The first being is that we can no longer guarantee for instance that CottonLOGIC will even work with future releases of Windows. The software is considerably dated and users are finding this frustrating.
- Secondly, because of the way CottonLOGIC is programmed it is becoming more difficult to enhance its features. There are some features that we cannot include.

The solution is a challenge in itself. For our software to meet the future needs of the industry it will mean a major rewrite of CottonLOGIC. We have put considerable planning and thought into this and come up with a solution that will both meet the future needs of the industry and preventing a similar situation from happening again. We need to have software suitable for the future computer environments, not necessarily on what we have now. To undertake this task although, will mean considerable resources for the next two years, without any direct visible outcomes.

Maintaining resources without direct outcomes will be a considerable challenge for the cotton management support systems team, and will need support from the industry before committing.

Defining the role of Cotton CRC's website

There has been general agreement within the Cotton CRC that the role of its website is to deliver research information. Some frustration often occurs because of the lack of understanding of this role, which defines the boundaries of what it aims to deliver. Focus has been redirected to enhance this role and remove distractions that come about by trying to undertake other tasks. ACGRA could play a role in promoting this message.

IPM and Area Wide Management

It is widely recognised that CottonLOGIC in some areas of IPM is lacking. A workshop in the near future being planned by Lewis Wilson, Ingrid Christianson and some members of the cotton management support team will be conducted to develop a blueprint for IPM for CottonLOGIC for the future. It has also been recognised that resources will be required to help develop any initiatives that come out of this workshop for implementation into DSS.

Presently the DSS group is getting a number of enquiries about assistance in developing tools to assist with Area wide management (AWM) initiatives. Most proposals are not clearly defined and there is no path for any software development. A scoping study may need to be undertaken to develop a plan for software development to meet a wider range of industry needs. The Cotton CRC potentially will undertake the role of facilitating the exploration and development of the needs of AWM.

Maintaining Funding

As with any research program maintaining funding is important. A situation arises when there are many projects from a few different sources funding a similar initiative. It becomes very difficult to get new initiatives started when there is pressure trying to maintain existing ones.

Another issue is the ramping down of the Cotton CRC funding and where the Cotton CRC it is heading in the future. A question remains how does cotton decision support fit into any future planning and what role if any will require funding to the CSIRO cotton management systems support team.

The way cotton decision support is funded may be an issue ACGRA wish to discuss.

Conclusion

We in the cotton industry are in an enviable position with an agricultural industry rich with successes in computerised decision support. With an agreed and coordinated approach, working close with industry we can help seek to maintain this success now, and into the future.