Cotton Catchment Communities CRC

FINAL REPORT

(due within 3 months on completion of project)

Part 1 - Summary Details

Cotton CRC Project Number: **1.1.16**

Project Title: Facilitating IPM adoption in northern region broadacre farming systems

Project Commencement Date: 01/07/2004 **Project Completion Date:** 30/06/2009

Cotton CRC Program: The Farm

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Part 3 – Final Report Guide (due within 3 months on completion of project)

Background

This project was jointly funded by GRDC (75%) and CRDC (25%) for 3 years. The joint funding is a clear indication of the cross-industry, farming systems approach being taken. At the end of the three years (2006), we had significant unspent funds as a result of the drought impacting on the execution of some of our planned activities. We requested an extension of the project for 2 years, without any additional funding which allowed us to fully use the unspent funds. The extension was granted, the project running for a total of 5 years.

Facilitating adoption of IPM in northern region broadacre farming systems

Over the past decade, the cotton industry has seen a marked transition in attitude towards insect pest management. In all regions, both mixed farming systems (cotton & grains) and predominantly cotton systems, there has been considerable interest in, and experimentation with area-wide management of pests (AWM), and integrated pest management (IPM).

However, there still remain considerable challenges to the sustained implementation of IPM in these farming systems. A major challenge to grower confidence is keeping abreast of changes in knowledge. Growers need to know that pest management recommendations will still be appropriate given changes that are occurring on their farms and to their cropping system. For example, how pest abundance and/or dynamics might be affected by the the mix of transgenic and conventional cotton, and the accompanying changes in crop agronomy and management. The sustainability of many cotton-growing enterprises is reliant not only on the production of cotton itself, but also on grain crops. Therefore, from a farming systems perspective, it is important that information on pest management not be restricted to cotton, but encompasses the gamut of crops and rotations that cotton-growers are using. Many of the pests that cotton-growers manage in cotton crops will also be encountered in non-cotton crops, and the management of a pest population in one crop may have significant implications for its ongoing management on that farm, or the region.

The ongoing development of an IRMS, which encompasses chemical use in both cotton and grain crops season-long, needs to be informed of changes in the flow of major pests between cotton crops and grain crops. It is important that the IRMS takes into consideration the management practices and challenges facing non-cotton crops, in order to ensure the development of resistance to products is managed in a farming systems context.

Working with groups of growers, on-farm demonstration trials and collaborative research with growers and consultants have proven to be effective tools in encouraging the uptake of IPM and AWM, and in effecting changes in attitude and practice. The ongoing maintenance of close relationships with growers, their advisers, and with colleagues in research and extension, is essential to facilitating the recognition of research outcomes and the uptake of new tactics and strategies.

Review of Farmscaping

Farmscaping is a concept that appears to have potential to faciliate Integrated Pest Management (IPM) in mixed cropping systems, and contribute to the management of resistance to transgenic crops. The idea that by manipulating the farm/field landscape it is possible to disadvantage pest species, and advantage natural enemies, is key to the

Farmscaping concept. In recent years the low rainfall, and low cotton crop areas have limited the opportunities to test farmscaping theories in the field. A review of the literature on theoretical and practical approaches to farmscaping was proposed with a view to identifying if and how farmscaping may be pursued to provide benefits to the cotton industry in Australia.

Objectives

Participation in the cotton industry to facilitate the adoption of IPM

Facilitating the adoption of IPM through providing support to industry has been the key focus of this project. The project team has been involved in a wide range of activities that have, in combination, met this objective. The major areas of activity contributing to the achievement of this objective have been:

- *Contribution of expertise to the development and delivery of skills training to industry*
  Participation of the project team in a large number of activities related to learning about pest management have contributed to the maintenance of grower and consultant knowledge of IPM and AWM. Hands-on field activities and the dissemination of technical information have addressed the needs of a wide section of the cotton industry, from students (UNE Cotton Production Course) to growers and their advisers (field days, IPM Shortcourse, industry presentations). The project team played an important role in equipping growers and consultants in southern Queensland (Darling Downs, St George and Byee) to learn from the silverleaf whitefly (SLW) outbreak in 2005-06, and manage subsequent SLW infestations. In addition to these activities in cotton, project team members have prepared and participated in a wide range of similar activities in the grains industry, particularly focusing on the pulses (chickpea, soybean and mungbean).

- *Maintaining communication between QPIF research group and industry*
  Communication with industry is one of the great strengths of the QPIF Entomology group, and this has been evident through this project. Communication of technical information, to support grower and consultant decision-making, has been made more responsive and the information more widely accessible through the adoption of Web 2.0 technologies in the form of the Beatsheet blog. Cotton-related articles/discussions posted on the blog are regularly accessed 100-200 times.

  The project team has contributed significantly to the establishment of an IPM Website within the DEEDI/QPIF on-line environment. The aim of this website is to bring together into one site the pest management information that has previously been scattered through the cropping pages. This project is partially funded by the National Invertebrate Pest Initiative (NIPI), which is funded by GRDC. Information on the website provides information on insect pests of broadacre field crops from two perspectives. One is the A-Z of pests and natural enemies, and the other is crop pages. The website also provides information on identification, thresholds (where available), and links to relevant sites. The cotton pages are not yet complete, but will be when the project ends in November 2010.

- *Playing an active role in grower groups and CCA activities*
  Ongoing engagement with growers and their advisers has played an important part in supporting the adoption of IPM, and builds on lessons learned through the Helicoverpa AWM project. The project team has maintained regular contact with local grower groups, attending meetings when invited. In recent years the regularity of grower group meetings has declined, but members of the project team have attended a number of meetings of advisers (agronomists and consultants) to present information on pest activity and management. Attendance at the monthly meetings of the local CCA (Crop Consultants Australia) group have provided valuable opportunity for two-way discussion of management recommendations and practical issues associated with managing pests and implementing IPM.

- *Responding to industry enquiries*
  Responding to a large volume of phone and email enquiries is another way in which the project team has ensured its ongoing support for the implementation of IPM. Growers and consultants often need a 'sounding board' to discuss the options and further their understanding of the implications of any course of action. Whilst growers and consultants are reporting that they are finding the Beatsheet Blog useful in setting out the important issues, they often still want to discuss their own individual situation, or take the discussion further.

Research contributing to the development of insect pest management tactics and IPM

Evaluate new chemistry in the context of a farming systems IRMS.

The preservation of natural enemies in the farming system is of benefit to all crops. Sorghum and winter cereals represent significant sources of a wide range of natural enemies (predators and parsitoid wasps in particular) which make a valuable contribution to IPM in cotton, particularly in the mixed farming systems of the Darling Downs. Therefore, the use of 'softer' options in these crops is highly desirable. In this project we evaluated a number of soft options (indoxacarb, firpronil, metarhizium, dimethoate + salt) for the control of Rutherglen bug in sorghum and sunflowers. Unfortunately, none of these options offered adequate levels of control compared with the currently registered, and highly disruptive, synthetic pyrethroids.

Further research, under the auspices of GRDC-funded projects, will progress the development of economic thresholds and appropriate timing of control for Rutherglen bug, and cereal aphids with a view to reducing the likelihood of unwarranted control being applied. Similarly, the emergence of new soft options will be investigated for these target pests and for armyworm in winter cereals.

Qualitative and quantitative evaluation of the impact of Bollgard II on the activity of Helicoverpa

Data documenting pest abundance (and more recently natural enemy abundance), and insecticide use in cotton crops have been collected for a number of properties on the Darling Downs (2004-2006). These data build on the dataset previously collected during the Helicoverpa AWM project (1998-2003). This dataset represents an important resource for mapping changes in practice and pest pressure over time.

However, it has not been possible to fully achieve the objective of evaluating the impact of Bollgard II from reviewing these data. Difficulties were encountered in standardising the data across the years in order to develop a database that could be analysed. The analysis of these data is still being pursued.

Other activities

The project team has made a significant contribution to a wide range of cotton-related research projects through the collection of helicoverpa larvae in the field (resistance testing), the provision of helicoverpa larvae from culture (transgenic development, student projects) and the collection of data that allowed the validation of the SLW population growth model for southern Queensland.

Preliminary trials on symphyla isolated from cotton crops in Theodore in 2008 have demonstrated that these organisms are generating the symptoms (stunted root growth) affecting large areas of some farms in the area. Further work is required to establish a threshold and determine effective management strategies for the affected farms. This work has been done in conjunction with Susan Maas, Emerald.

Complete a review of Farmscaping

The review of literature related to farmscaping has been completed and recommendations made as to future directions for research in this area.

Methodology and Outcomes

Participation in the cotton industry to facilitate the adoption of IPM

Facilitating the adoption of IPM has been the key focus of this project. The project team has been involved in a wide range of activities that have, in combination, met this objective. The major areas of activity contributing to the achievement of this objective have been:

Contribution of expertise to the development and delivery of skills training to industry

The project team has actively participated in a large number of industry activities, extending technical information on insect identification, management and IPM and AWM. Target audiences have included growers, consultants and agronomists, extension staff and research colleagues. The vehicles for skills training include:

- the annual residential unit of the UNE Cotton Production Course – presentation of a module on AWM and IPM (2004-2008)
- the Cotton IPM Shortcourse – theory and field components (2004)
- field days – pest activity updates, SLW identification, sampling and management (Dalby, St George, Byee 2005-06)

- hands-on sessions at the ACGRA Cotton Conference (2006) – identification and management of SLW
- the SLW roadshow (2006) and the annual Resistance Roadshow – presentation of relevant local information on pest activity at agronomy technical symposia. The Development Extension Officer (Austin McLennan and then Kate Charleston) have been members of the Cotton Extension Team.

Importantly, activities in this area have contributed significantly to the capacity of growers and their advisers to identify key pests and management options. Of particular importance has been the team's involvement with the industry though the SLW outbreaks on the Downs, Byee and St George in the 2005-06 season. Field days, data collection from the regions and facilitating grower meetings with Paul Grundy and Richard Sequeira ensured the industry was as informed as possible to manage the outbreak.

Maintaining communication between QPIF research group and industry

Through regular participation in a wide range of industry activities, the project team maintains networks and communication with growers, consultants, other researchers and stakeholders. Internally, this project has had strong links with other QPIF research projects (Khan – mirids, GVB, cotton stainers; Ludgate – SLW) which has ensured that outcomes of this research can be rapidly communicated to industry through appropriate networks and activities. Close links and collaboration with NSW DII and CSIRO projects have similarly resulted in information from these projects being widely disseminated (e.g. western flower thrip surveys, bunchy top risk, Bt resistance monitoring, helicoverpa resistance monitoring)

The Beatsheet blog (www.thebeatsheet.com.au) has been the primary vehicle for the regular communication of technical information and discussion of pest management options between QPIF Entomology and the cotton industry. The newsletter format was converted to a web-based blog in 2007 in order to make the information widely accessible, and allow the rapid 'posting' of information as issues arose. The blog format provides the opportunity for two-way communication between QPIF researchers making postings and those reading them via on-line comments. However, this facility is not often used by industry, with growers and consultants still preferring to speak to researchers by phone or email.

Each year, from 2005-2008, the QPIF Entomology team has hosted the 2-day IPM Forum with around 40-50 participants each year. The Forum brought together researchers and key industry representatives from both cotton and grains industries to speak about their research and extension activities. This event has made a major contribution to the communication of research outcomes and activities between researchers and to key consultants, bridging regions and industries.

The project team has two members (Dave Murray and Melina Miles) on the TIMS conventional insecticide technical panel. Dave Murray also sits on the TIMS trouble shooting panel, and is the grains representative on TIMS. In these roles, the researchers provide technical input into discussion. For example, changes to the pupae busting recommendations, and the Steward® window in chickpea.

The project team has actively contributed to a number of cotton-industry research reviews and meetings, including the Aphid Management Review (2007), the Research and Extension in Resistance workshop (2007), the Mirid Reviews (2004 & 2007), the Cotton Biosecurity Plan (2007), REFCOM (2008, 2009) and the annual CRC Research Reviews (2005-2009). In addition, project members contributed to the review of the IPM Guidelines (2007).

Playing an active role in grower groups and CCA activities

In facilitating the adoption of IPM it is critical to be constantly involved with industry, providing information, discussion and support. To this end the project team has maintained an active role in grower group meetings (Downs, St George) to discuss SLW and other issues generally. Dave Murray regularly presented information to agronomists and consultants (e.g. Landmark, CCA seminars) providing updates on pest management recommendations.

Each month one, or more team members, attends the local (Dalby) meeting of the CCA. These meetings are a valuable forum for discussion on pest management options, and the implications of different approaches. They are also invaluable opportunities for the local consultants to raise with the QPIF research and extension staff issues that they feel warrant attention.

Responding to industry enquiries

Support for growers and consultants, as they manage their crops, has proven essential in promoting the implementation of IPM in cotton. The project team responds to a large volume of telephone and email enquiries during the cotton season. Enquiries cover a wide range of topics e.g. insect identification, thresholds, insecticide options, and strategies for managing multiple and sequential pests. The Beatsheet blog has enabled us to add value to the time spent on these enquiries by ensuring that discussion of the key issues are posted, making them more widely available, and archiving the information for retrieval at a later date.

In addition, the project team has provided interviews to the popular press and industry media (e.g. CSD Web).

Research contributing to the development of insect pest management tactics and IPM

Evaluate new chemistry in the context of a farming systems IRMS.

The focus of this outcome is to identify insecticide options that are less disruptive to the farming system as a whole. The underlying principle of this work is that many of the crops in the system play an important role as sources of natural enemy populations, particularly parasitoid wasps, which benefit the system as a whole.

During the project, soft options for Rutherglen bug (*Nysius vinitor*) were explored in sorghum and sunflower. In both instances synthetic pyrethroids are generally used to control this pest. Trial results showed that synthetic pyrethroids were the most cost effective and efficacious products, with soft options (e.g. indoxacarb, fipronil, metarhizium, reduced rate dimethoate + salt) giving unacceptably low levels of control.

Further research funded by GRDC, is ongoing to clarify economic thresholds for Rutherglen bug in sorghum and the appropriate timing of insecticide applications, with the aim of reducing the likelihood of unwarranted or ill timed spraying.

No further opportunities for testing soft options arose during the project, and armyworm and aphids in winter cereals remain particular areas of interest.

Qualitative and quantitative evaluation of the impact of Bollgard II on the activity of Helicoverpa

Consultant data, detailing pest pressure and insecticide control, represents an important historical record of pest management. These data was collected from 1998-2001 under the *Helicoverpa regional management* project (area wide management), and continued under this project. The records are complete from 1998-2006.

Initially, it was anticipated that these data would contribute to an understanding of any changes in *Helicoverpa* abundance following the introduction of Bollgard II. However, the large volume of data, and the variability of the data across years, plus the relatively small sample in 2002-2006, has presented considerable challenges. The challenge of standardising the large dataset prior to any analysis has proven to be beyond the skills of the project team. As a result, this outcome has not been achieved.

We have, however, continued to explore options for having the data processed into a form in which it can be analysed, and it is presently with Professor Myron Zalucki at the University of Queensland.

Other activities

The project team has made a valuable contribution to various ongoing research and monitoring activities within the cotton industry.

Until mid 2008, the helicoverpa colony maintained by QPIF in Toowoomba supplied larvae to universities (UQ, University of Melbourne) and agrochemical companies involved in the development and testing of products for the cotton industry.

The project team has made collections (Downs and St George) of larvae surviving on Bollgard II for testing by Sharon Downes, CSIRO, Narrabri. The team also collected helicoverpa larvae from a range of grain and cotton crops on the Downs, and Central Queensland, for inclusion in the insecticide resistance testing program of Louise Rossiter, NSW DII, Narrabri.

Following the SLW outbreaks in St George, the Downs and Byee in 2005-06, the project team collected fortnightly-weekly population growth and parasitism data from a number of fields on the Downs and St George. These data was used by Richard Sequeira (QPIF, Emerald) to validate for southern Queensland the SLW population growth model he had developed in Central Queensland. This work has provided the necessary evidence to demonstrate that the population model and associated management recommendations (timing of IGR use) are applicable to southern Queensland.

Collections of symphyla were made from affected field in Theodore and maintained in culture in Toowoomba. Pots containing germinating cotton plants were infested with symphyla and then roots examined for signs of damage. Control plants displayed normal root growth, but the root growth in the infested pots showed classic 'spear tipping' symptoms characteristic of symphyla damage.

Complete a review of Farmscaping

The review of literature related to farmscaping has been completed and recommendations made as to future directions for research in this area.

Outcomes

The planned project outcomes were to contribute to the sustained implementation of IPM in the cotton industry, and to facilitate a farming systems approach for IPM that encompassed both cotton and non-cotton crops.

The project has contributed towards these outcomes through a wide range of activities that have:

i) ensured that growers, consultants and researchers are kept abreast of research and developments related to pest management (field days, Beatsheet blog, presentation of technical information, IPM Forums, regular attendance at industry meetings, responding to enquiries and industry feedback),

ii) contributed to grower confidence that recommendations are appropriate to their individual situations (responding to enquiries, providing discussion of recommendations and options via the Blog, being available for discussion at field days and group meetings),

iii) evaluated tactics for compatibility with a farming systems approach to the management of insect pests and natural enemy populations (R, D & E to promote appropriate pest management in cotton and grains, promotion of natural enemies as a valuable resource, evaluation of soft options),

iv) contribution to the ongoing development of a farming systems based IRMS (representation of grains industry perspective on TIMS, evaluation of soft options in grains), and

v) provided ongoing support to the cotton industry in general through participation as collaborators in a wide range of R, D and E projects and activities.

The impact of the project activities on the cotton and grains industries, in terms of its contribution to the planned outcomes is difficult to quantify without a formal evaluation being undertaken. Such an evaluation was outside the scope of this project, but is an area which warrants some attention.

Conclusion

Ongoing research, development, extension and support are critical to sustaining the interest in IPM and facilitating its implementation. To achieve these outcomes requires a multifaceted approach that encompasses hands-on research, the maintenance of communication with all levels of industry, and the maintenance of effective networks amongst researchers and between researchers, and growers and their advisers. An approach that does not focus on crop, but on pest management, has proven to be a very effective. Growers and their advisers are constantly seeking sources of information and looking to increase their knowledge and understanding of pest management. To this end, they require ongoing access to individuals, or teams, who can guide and support them in their endeavours. Even with the increasing range of available information, published and on-line, there is an ongoing demand for personal interaction to discuss and learn.

Extension Opportunities

Broadening the scope of the Beatsheet Blog

A readily accessible vehicle for two-way communication between those conducting R, D and E and industry has potentially broader applications that we are currently using. The Beatsheet Blog has potential to be developed so that it supports greater discussion (forums), and interaction (follow up to field days and workshops, on-line exercises as part of accreditation and/or seasonal refreshers). The Beatsheet blog has recently been ported to new software that will enable these types of applications to be trialled.

Future research

One of the handicaps that a wide ranging project, such as this, faces is evaluating the relative impact of the various activities in order to guide future activities. Research into the evaluation of IPM related activities is warranted. Any evaluation would benefit from being taking a cross industry, farming systems, approach to try and overcome the difficulties associated with trying to attribute the impact of activities/research outputs related to individual crops. In other words, asking growers and their advisers about their attitudes, knowledge and practices of pest management in general, rather than specifically related to cotton.

Publications arising from the project

1) Cotton-industry specific publications

Technical brochures

Understanding *Helicoverpa* ecology and biology in southern Queensland: Know the enemy to manage it better (12 pp colour) 2005. QDPI&F

Microplitis demolitor and ascovirus: Important natural enemies of helicoverpa (8 pp colour). 2005 QDPI&F.

Parasitoids: Natural enemies of helicoverpa (12 pp colour). 2005. QDPI&F.

Using NPV to manage helicoverpa in field crops (8 pp colour). 2005. QDPI&F.

Seminars and conferences

Murray D and Miles M. 2009. Broadacre crop pest update. CCA Cropping Solutions Seminar. Goondiwindi.
Miles M. 2009. Areawide management of Silverleaf Whitefly. CCA Cropping Solutions Seminar. CCA Cropping Solutions Seminar. Goondiwindi.

McLennan AJ. 2006. Before, during and after the crisis: 8 years of extension for IPM adoption in southern Queensland farming systems (1998-2006). In Practice change for sustainable communities: Exploring footprints, pathways and possibilities. Pethram RJ and Johnson RC (eds) APEN 2006 International Conference, LaTrobe University, Beechworth, Victoria, Australia 6-8 March 2006. Online at www.regional.org.au/au/apen/2006.

Scientific papers

Brier HB, Murray DAH, Wilson LJ, Nicholas AH, Miles MM, Grundy PR and McLennan AJ. 2008. An overview of integrated pest management (IPM) in north-eastern Australian grain farming systems: past present and future prospects. *Australian Journal of Experimental Agriculture* 12: 1574-1593.

Lloyd RJ, Murray DAH and Hopkinson JE. 2008. Abundance and mortality of overwintering pupae of *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) on the Darling Downs, Queensland, Australia. *Australian Journal of Entomology* 47: 297-306.

Buerger, P., Hauxwell, C. and Murray, D. 2007. Nucleopolyhedrovirus introduction in Australia. *Virologica Sinica* 22:173-179.

Cleary AJ, Cribb B and Murray DAH. 2006. *Helicoverpa armigera*: can wheat stubble protect cotton plants against attack? *Australian Journal of Entomology* 45: 10-15.

Christian PD, Murray DAH Aigner R, Hopkinson JE, Gibb NN, and Hanzlik TN. 2005. Effective control of a field population of the cotton bollworm using the small RNA virus, Helicoverpa stunt virus (Omegatetravirus, Tetraviridae). *Journal of Economic Entomology* 98: 1839-1847.

Scott KD, Lawrence N, Lange CL, Scott LJ, Wilkinson KS, Merritt MA, Miles M, Murray D and Graham GC. 2005. Assessing moth migration and population structuring in the cotton bollworm *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae) at the regional scale: Example from the Darling Downs, Australia. *Journal of Economic Entomology* 98: 2210-2219.

Popular press and industry publications

Rossiter, L. Farrell, T., Larsen, D., Kauter, G., Downes, S., Wilson, L., Murray, D. and Miles, M. 2008. Insecticide Resistance Management Strategy (IRMS) for 2007/08. In Farrell, T. (ed) *Cotton Pest Management Guide*. NSW DPI.

Rossiter L, Murray D, Miles M, Downes S, Wilson L and Kauter G. 2007. Better pupae busting decisions in sprayed conventional cotton. *The Australian Cottongrower* 28: 21-22.

Murray D, Lloyd R and Hopkinson JE. 2005. Predators make big screen debut. *The Australian Cottongrower* 26 (2): 10-12.

Media releases

February 2008. Whitefly alert (GRDC MR)

Online resources

1) The Beatsheet blog can be viewed at www.thebeatsheet.com.au

Cotton-focused postings listed are a subset of the 42 articles posted between July 2007 and July 2009.

Postings	**Date Posted**	**Authors***
Resistance Update on the Road	10 Sep 2009	DM
Detection of Q biotype *Bemisia tabaci* in Australia	28 Apr 2009	ZL and DM
Late season pests of pulses and cotton	20 Feb 2009	KC and HB
Silverleaf whitefly update	11 Feb 2009	ZL
Silverleaf whitefly in cotton – an update	23 Jan 2009	ZL
Insurance sprays for mirids in Bollgard II	19 Dec 2008	MK
Farm hygiene important in pest management	17 Apr 2008	DM
Accessing the diapause tool – an alternative address	27 Mar 2008	MM
Diapause tool to identify helicoverpa risk	20 Mar 2008	DM
Whitefly management options	29 Feb 2008	MM
Whitefly Update	22 Feb 2008	MM
Whitefly in crops this season	8 Feb 2008	MM
Friendly fighter conquers foe	30 Nov 2007	DM
St George growers meet to discuss area-wide SLW management	16 Aug 2007	MM
IPM Researchers Forum 2007	2 Aug 2007	DM
The Beat Sheet is now a blog	11 Jul 2007	AM

*AM = Austin McLennan, DM = David Murray, HB = Hugh Brier, KC = Kate Charleston, MK = Moazzem Khan, MM = Melina Miles, ZL = Zara Ludgate.

2) The DEEDI/QPIF IPM website can be accessed via the following URL http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/26_3510_ENA_HTML.htm

or by the following series of steps (Primary Industries and Fisheries website (www.dpi.qld.gov.au) – Plants – Field crops and pastures – Broadacre field crops – Insect Management (Crops & Diseases) = Managing insect pests in field crops)

2) Additional publications arising from the project (grains related)

Press Releases

- November 2008- New guidelines for chickpea pest control (Crop Doctor)
- February 2008 – Whitefly alert (QDPI&F MR)
- February 2008 – Rutherglen bug impact on yield (Crop Doctor)
- January 2008 – Bugs put bite on sorghum yield potential (QDPI&F)
- December 2007 – NPV for helicoverpa management (QDPI&F MR)
- November 2007 – Rutherglen bug at harvest (GRDC MR)
- October 2007 – Corn earworm outbreak emerging in CQ (Crop Doctor)
- October 2007 – Watch for armyworm in barley and oats (Crop Doctor)
- October 2007 – Identifying armyworm and helicoverpa in winter cereals (Crop Doctor)
- September 2007 – Managing cereal aphids (Crop Doctor)

These media releases (MRs) were picked up by a range of media including ABC rural radio (5 interviews) and Rural press, including the Queensland Country Life.

Articles – *Ground Cover*

Anon. 2009. Crickets in soy feast. *Ground Cover* 80: 33.
Anon. 2009. Growers urged to revise sorghum pest thresholds. *Ground Cover* 79: 37.
Leonard, E. 2009. Species dominance makes a difference. *Ground Cover* IPM supplement May-June
Bowman, R. 2008. Researchers build sorghum data. *Ground Cover* 74: 31.
Leonard, E. 2008. Beat sheet blog leads bug bust. *Ground Cover* 72: 24.
Reppel, B. 2006. IPM needs forward planning. *Ground Cover* 65: 24.
Murray, D. 2006. The good and the bad of sorghum pests. *Ground Cover* 61: 23.
Anon. 2005. Cropcam catches mice giving farmers a hand. *Ground Cover* 54: 18.

Articles – Popular Press

Charleston, K. 2009. IPM in the northern region. *Australian Grain* 19(2): vii-viii (Northern Focus).
Charleston, K. 2009. IPM in grain sorghum – an Australian success story. *Australian Grain* 18(6): 12-14.
Anon. 2008. New pest control thresholds for chickpeas. *Australian Grain* 18(4): vii-viii (Northern Focus).
Anon. 2008. Crop Doctor. New trials gauge Rutherglen bug yield impacts. *Australian Grain* 17(6): viii (Northern Focus).
Miles, M., Lloyd, R., Murray, D. and Hauxwell, C. 2008. New research on the impact and control of Rutherglen bug in sorghum. *Australian Grain* 17(5): i-iii (Northern Focus)
Anon. 2008. The cost of midge damage. *Australian Grain* 17(5): iv (Northern Focus).
Anon. 2007. Rutherglen bugs taint harvested grain. *Australian Grain* 17(4): iv (Northern Focus).
Miles, M., Grundy, P., Lloyd, R. and Short, S. 2007. *Helicoverpa* impact on chickpea yield and quality. *Australian Grain* 17(2): 4-7.
Anon. 2005. Hounding heliothis. *Australian Grain* 15(3): vii (Northern Focus).

GRDC Grower and Adviser Update papers

Miles, M., Shatte, T. and Murray, D. 2008. Rutherglen bug, sorghum midge and diagnosing poor seed set in grain sorghum. GRDC Update Dalby, August 2008.
Miles, M., Grundy, P., Lloyd, R. and Short, S. 2007. *Helicoverpa* impact on chickpea yield and quality – new data and recommendations. GRDC Update Dubbo, February 2007.
Miles, M., Grundy, P., Lloyd, R. and Short, S. 2007. *Helicoverpa* impact on chickpea yield and quality – new data and recommendations. GRDC Update Goondiwindi, February 2007.
Miles, M., Lloyd, R. and Murray, D. 2007. Managing Rutherglen bug in grain sorghum – new research on impact and control. GRDC Update Goondiwindi, February 2007.
Miles, M. and Hardy, A. 2007. Late season insect pests management in sorghum – when to react. GRDC Update Dalby, February 2007.
Murray, D., Hardy, A. and Scholz, B. 2005. Insects in sorghum – the good, the bad, the ugly – finding the balance. GRDC Update Central Queensland, August 2005.
Murray, D. and Hardy, A. 2005. Insect pests in sorghum – when to react? GRDC Update Goondiwindi, February 2005.

Other publications

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Murray, D.A.H., Lloyd, R.J. and Hopkinson, J.E. 2005. New insecticides for *Helicoverpa* spp. (Lepidoptera: Noctuidae) management in grains. *Australian Journal of Entomology* 44:62-67.

Beat Sheet Blog postings

Title	Date Posted	Authors*
Slaters and other winter cereal establishment pests	28 May 2009	KC and DM
What is eating my soybean pods?	6 Mar 2009	DM and KC
Mirids in mungbeans	26 Feb 2009	KC and HB
Soybean moth causing major damage in soybeans	13 Feb 2009	KC and HB
Silverleaf whitefly update	11 Feb 2009	ZL
Latest helicoverpa thresholds for mungbeans	30 Jan 2009	HB
New helicoverpa thresholds in vegetative soybeans	15 Jan 2009	HB and KC
Thresholds and changing sorghum crop value	16 Dec 2008	DM
Bring on NPV against grubs in grain sorghum	26 Nov 2008	DM
Managing helicoverpa larvae in chickpea crops close to dessication and harvest	5 Nov 2008	MM

Armyworm in wheat	20 Oct 2008	MM
Helicoverpa management in chickpea – a refresher	8 Oct 2008	MM
What are those grubs in winter cereals?	1 Oct 2008	DM
Cereal aphids in wheat and barley Spring 2008	25 Sep 2008	
Farm hygiene important in pest management	17 Apr 2008	DM
Accessing the diapause tool – an alternative address	27 Mar 2008	MM
Diapause tool to identify helicoverpa risk	20 Mar 2008	DM
Whitefly management options	29 Feb 2008	MM
Whitefly Update	22 Feb 2008	MM
Whitefly in crops this season	8 Feb 2008	MM
Will Rutherglen bug damage sorghum post grain filling?	16 Jan 2008	MM
Watch out for midge this season	9 Jan 2008	MM
Rutherglen bug in sorghum	21 Dec 2007	MM
Getting the most from NPV sprays on grain sorghum	14 Dec 2007	DM
Friendly fighter conquers foe	30 Nov 2007	DM
Corn earworm chews into sorghum profits	16 Nov 2007	DM
Rutherglen bugs are everywhere!	2 Nov 2007	MM
No concern for tell-tale holes	2 Nov 2007	DM
Can you confidently identify armyworm and helicoverpa in winter cereals	17 Oct 2007	MM
Control considerations for helicoverpa in chickpea	10 Oct 2007	MM
Are corn earworm a problem in winter cereals?	1 Oct 2007	DM
Watch for armyworm in wheat and barley	21 Sep 2007	DM
Cereal aphid update	4 Sep 2007	MM
Are aphids sucking away cereal profits	23 Aug 2007	DM
A better way to make decisions about helicoverpa control in chickpea	16 Aug 2007	MM
IPM Researchers Forum 2007	2 Aug 2007	DM
The Beat Sheet is now a blog	11 Jul 2007	AM

*AM = Austin McLennan, DM = David Murray, HB = Hugh Brier, KC = Kate Charleston, MK = Moazzem Khan, MM = Melina Miles, ZL = Zara Ludgate.

Training Courses

What	Where	When	Who*	No. participants
Industry Accredited Chickpea Course	Dalby	27-28 May 2009	DM, KC	12
Industry Accredited Chickpea Course	Goondiwindi	31 Mar – 1 Apr 2009	DM, KC	27
Soybean/Pulse IPM Course	Mackay	24-25 March 2009	HB, KC	12

Industry Accredited Chickpea Course	Narrabri	24-25 March 2009	DM	26
Industry Accredited Chickpea Course	Emerald	17-18 March 2009	HB, KC	14
Soybean/Pulse IPM Course	Isis/Childers	5-6 February 2009	HB, KC	36
Soybean/Pulse IPM Course	Bundaberg	4-5 February 2009	HB, KC	15
Soybean/Pulse IPM Course	Maryborough	2-3 February 2009	HB, KC	22
Soybean/Pulse IPM Courses (2)	Ayr	9-10 September 2008	HB, KC, DM	45
Soybean/Pulse IPM Course	Mackay	12 September 2008	HB, KC, DM	42
Soybean/Pulse IPM Course	Mackay	11 December 2007	HB, DM	40
Industry Accredited Mungbean Course	Narrabri	17-18 Oct 2007	HB, MM	18
Industry Accredited Mungbean Course	Dalby	11-12 Oct 2007	HB, MM	15
Industry Accredited Mungbean Course	Emerald	5-6 Sep 2007	HB, DM	6
Industry Accredited Chickpea Course	Dalby	8-9 May 2007	MM	19
Industry Accredited Chickpea Course	Narrabri	2-3 May 2007	MM	26
Industry Accredited Chickpea Course	Goondiwindi	26-27 Apr 2007	MM	23
Industry Accredited Chickpea Course	Emerald	17-18 Apr 2007	PG	14

Many of the above activities were conducted jointly with DAQ00086.
* AM = Austin McLennan, DM = David Murray, KC = Kate Charleston, HB = Hugh Brier, MK = Moazzem Khan, MM = Melina Miles, PG = Paul Grundy, ZL = Zara Ludgate,

Workshops/Forums

What	Where	When	No. participants
Northern IPM Project Review and Planning Meeting	Toowoomba	22-23 July 2009	12
Northern Farming Systems IPM Researchers Forum	Toowoomba	25-26 June 2008	45
Northern Farming Systems IPM Researchers Forum	Toowoomba	24-25 July 2007	49
Silverleaf Whitefly and Sucking Pest Workshop	Toowoomba	20-21 June 2006	34
Northern Farming Systems IPM Forum	Brisbane (in conjunction with NIPI)	27 July 2005	40

Part 4 – Final Report Executive Summary

Facilitating the implementation of IPM in northern broadacre farming systems

The focus of the project has been to provide support for growers and consultants of broadacre crops, as they attempt to implement IPM. The major pest species that attack cotton, are for the most part, not specific to cotton. Therefore, cotton-growers and their advisers are managing these pests across their farms, not just in cotton. Similarly, populations of natural enemies which are a vital component of IPM, breed, take refuge and feed across the landscape. With most cotton-growers also being grain-growers, they need ready access to information that encompasses the range of crops they grow. The aim of this project has been to facilitate the implementation of IPM throughout the farming system, raising awareness of the benefits, challenges and implications of different tactics. A farming systems approach was made possible through the joint funding of the project by CRDC and GRDC.

Achieving outcomes in a farming-systems context has been possible through having a multifaceted project bringing together research, development and extension simultaneously. Working with groups of growers and advisers, maintaining regular two-way communication with growers, consultants, agribusinesses and extension colleagues have been critical to facilitating the awareness of pest management strategies. Building on this awareness, the project has undertaken targetted research, and extension activities to provide detailed technical information that can be used in making management decisions. Critically, the project provided further support to growers and consultants attempting to implement IPM by ensuring access to researchers at industry meetings, field days and in person, to discuss the issues and respond to specific enquiries.

Collaboration with colleagues in research and extension, has been essential to achieving outcomes for industry in a range of area (an IRMS that accommodates both cotton and grains, SLW and other pest outbreaks). The industry networks and extension activities of this project have ensured the dissemination of research outcomes to industry as they have emerged, facilitating their uptake by industry. In addition, the project has facilitated discussion amongst researchers and industry via the annual IPM Forum, strengthening relationships and sharing research findings.

Farmscaping

Whilst many components of pest and natural enemy management on farms have been explored, it is difficult to determine whether the implementation of these on individual farms will result in significant direct benefits. It seems likely that in highly cultivated regions, a landscape approach will be necessary to achieve quantifiable benefits. However, the extent of knowledge in Australia of the ecology (particularly hosts, movement) of even our major pest and natural enemy species is currently insufficient to design farmscapes or landscapes that may deliver benefits.