Heliothis management in south Queensland farming systems

Summary
This project was a collaborative effort to develop, implement and evaluate sustainable management approaches for helicoverpa and other pests in the southern Queensland (QLD) agroecosystem that can lower reliance on conventional insecticides yet maintain profitability of farming enterprises. The project consolidated on the achievements of the previous regional management projects.

The project has promoted a 'clean and green' image to the broader community, consumers and trade partners, with obvious flow-on benefits for the agroecosystem.

There is an air of confidence among both cotton and grain growers that helicoverpa management issues are not currently a high priority production concern.

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Conclusions
Area-wide management strategy and helicoverpa management:
Helicoverpa slipped from being a high priority topic due to drought, low pest populations, new insecticides and the performance of Bacillus thuringiensis (Bt) transgenic cotton (Bollgard II). There is a growing confidence among growers and their advisers in their ability to manage pest outbreak years, but there was some reversion to old habits brought about by chemical supply shortages in December 2003. This chemical supply problem will be an ongoing issue as companies manage supplies to minimise carryover stock.

The egg parasite Trichogramma pretiosum has consolidated its importance for helicoverpa management on the Darling Downs, and efforts are now directed at enhancing its performance at the farmscape level.

As demonstrated by video surveillance, vertebrate and invertebrate predators may cause high mortality of helicoverpa prepupae. All the studies to date have been in dryland crops where it is speculated that predation will be greater compared to irrigated crops. The need to pupae bust late summer crops, and the implications of this, require more detailed assessment.

Insecticides and an Insecticide Resistance Management Strategy (IRMS):
New insecticides have delivered valuable cost-effective alternatives to grain growers. A farming systems IRMS is achievable, as demonstrated by the cooperative placement of Steward® to meet the needs of both the grains and cotton industries. This effort must be maintained into the future. Resistance to new insecticides remains a major sustainability threat, though it appears in low pest years this risk is greatly diminished.

Development and extension:
The project has demonstrated the value of development and extension activities to promote area-wide management (AWM)/integrated pest management (IPM) and to build levels of knowledge and skills.

Research, development and evaluation (RD&E) needs:
The national Helicoverpa Workshop reviewed AWM and indicated priorities for future direction of AWM.

Recommendations
Agrochemical companies will continue to develop new insecticides. There remains a cooperative role for project staff in the development and positioning of new products within a farming systems IRMS. The impact of new insecticides on natural enemies remains an area of continuing involvement. The adoption of Bt transgenic cotton (Bollgard II®) will lower the
selection pressure that cotton has previously placed on conventional insecticides, but this void will possibly be taken up by broad registrations in grain crops as companies seek to maintain a sales market. It is thus important that industry remains vigilant and that monitoring for insecticide resistance in *Helicoverpa armigera* be maintained at least at current levels.

Pest management in Australian farming systems will continue its reliance on insecticides. There are several pests for which the current registrations are for old insecticide groups with broad spectrum activity (e.g. pyrethroids for armyworms in winter cereals and Rutherglen bug in sorghum). The management of other pests must be compatible with IPM approaches, in particular, conservation of natural enemies and biodiversity in the agroecosystem. This approach also highlights the need for continuing development of an IRMS that is compatible with IPM while meeting resistance management requirements.

Pupae busting (full surface cultivation to 10cm depth) continues to pose a dilemma, particularly in dryland crops. Initial video monitoring indicates an important role of both invertebrate and vertebrate predators. Improved understanding of the species responsible and quantification of their contribution to reductions in pupal numbers could influence future pupae busting recommendations. Further investigations of helicoverpa prepupal and pupal predation are warranted, particularly in irrigated crops.

Promoting conservation of natural enemies is a key component of IPM programs. There is a list of what are considered 'important' predators, but unlike for parasitoids, it is unable to give specific advice to advisers and growers as to how important each predator species is, what prey constitute their diet, and why they are worth conserving. DNA techniques have the potential to deliver this knowledge. The 'proof of concept' to use DNA techniques, if successful, will enable researchers to identify the relative importance of different species in the predator guild, and ultimately assist pest management decision-making.

The status of helicoverpa as a pest in grains and cotton following the introduction of Bollgard II has significant implications for area-wide management of this pest. For historical purposes there is value in securing a long-term data set from cotton pest-checking records. On-going support for the annual assemblage of these data from representative farms is proposed.

Continuing support for the adoption of IPM across the northern grains region is suggested by working with groups to deal with specific insect pest issues (e.g. discussion, in-field demonstrations/field days, participative learning activities, skills training for both growers and agronomists), general extension to industry, raising awareness of new and existing issues within the industry, contributing to the development and testing of decision support tools (e.g. pest development models to facilitate timing of control, diapause and emergence models for helicoverpa) and evaluation of the status of grower awareness, knowledge and application of IPM.

**Outcomes**

At the start of this project, all helicoverpa susceptible crops were at a crossroads with regard to helicoverpa management. Given the history of insecticide resistance in *H. armigera*, new chemical compounds could be expected to last less than 10 years in the absence of an IRMS and consequent overuse. In the absence of research into helicoverpa management, yields would decline and costs of production increase, rendering the production of some crops unprofitable and non-viable. An increased awareness and knowledge amongst grain growers and their advisers of helicoverpa management, within the context of AWM, IPM and an IRMS, has delivered improved management with less reliance on conventional disruptive insecticides. Projects DAQ364 and DAQ442 have laid solid foundations for the continuing RD&E program that links with other established networks (e.g. Pulse Australia, Adviser and Grower Updates, etc). DAQ539 has consolidated these previous developments.

This project has promoted a 'clean and green' image to the broader community, consumers and trade partners with obvious flow-on benefits for the agroecosystem. Under the current situation, there is an air of confidence among grain growers that insect management issues are no longer a high priority production concern. Project staff are aware of no instances of crop losses resulting from poor helicoverpa control (and associated with insecticide resistance) in the past two seasons. Three seasons of relatively low helicoverpa activity associated with drought conditions have probably benefited these outcomes.

Economic:

An analysis of the benefits of the AWM/IPM program in the Australian cotton industry was conducted by the Australian Cotton Cooperative Research Centre (CRC). The adoption of IPM and reduced pesticide use delivered total estimated benefits of $250 million. Longer term, intangible benefits of this research include reduced selection pressure for pesticide resistance,
reduced environmental impact and, as a result, enhanced sustainability.

Environmental:
A major achievement of this project is the almost total displacement of conventional insecticides for helicoverpa management on grain sorghum. This has reduced the insecticide burden on the environment, eliminated residues on potential stockfeed supplies, and served to conserve biodiversity. While impacts are not as spectacular for other grain crops, the availability and use of new, more selective insecticides is delivering positive environmental outcomes through improved biodiversity.

Social:
Over the past three years community action groups objecting to insecticide use have been conspicuous by their absence. Various factors (drought, relatively low pest activity, Bt transgenic cotton, reduced insecticide use, more ‘clean and safe’ options) have contributed to this development. At the local level it has also led to more harmonious interactions between neighbours. There has also been a building of social capital through training and education.

Achievements/Benefits
Helicoverpa attack a wide range of food, fibre, oilseed and fodder crops throughout Australia. The current conservative estimate of total economic damage and management control costs for helicoverpa in Australia is $200-300 million per annum. There is a high dependence on insecticides for the management of helicoverpa in all crops. Over-reliance on insecticides has led to declining efficacy of registered insecticides because of resistance in *H. armigera*, more frequent field control failures, and increasing pest densities. Under greatest threat have been the grains industries, for they have been highly dependent on ‘old’ compounds for helicoverpa management. There are also increasing concerns about environmental and human health hazards associated with insecticide use. This situation has needed to change if cropping on the Darling Downs (and elsewhere) is to remain economically viable, environmentally sustainable and socially responsible.

Regional or AWM strategies for helicoverpa have been developed in an effort to lower the ceiling of helicoverpa population densities and make crop production sustainable. AWM strategies are community-based pest management approaches that incorporate IPM, IRM and current Best Management Practice (BMP) components. While many predators, parasites and pathogens attack helicoverpa, these cannot always be relied on to maintain helicoverpa below economically damaging levels. There has been an urgent need to evaluate alternative treatments for helicoverpa management, giving preference for treatments that will reduce dependence on conventional disruptive insecticides while maintaining profitable and sustainable farming enterprises. Significant progress has been made in the development, registration and adoption of more selective biocides such as nuclear polyhedrosis virus (NPV) and Bt. At the start of this project, some new selective insecticides were approaching registration in grain crops and effort was needed to understand and promote their fit into IPM programs. Other pests, particularly sucking insects, may increase in importance as newer selective compounds replace the current broad spectrum compounds. Once again it is imperative that there is a coordinated effort to understand the interactions that take place and lessen the impact of these pests on productivity. There are established links with current research in the grains and cotton industries, and this project has built on those linkages through the annual project evaluation and planning process.

The project investigated the following aspects of pest management:
- The success/impact of AWM and IPM components on the Darling Downs
- Additional tools and tactics for pest management, including trap crops and refuges
- Survivorship of large helicoverpa larvae through to pupae
- New insecticides and their effect on pests and beneficials
- A farming systems insecticide resistance management strategy
- Improved performance of ingestion-active insecticides
- Development and extension activities related to AWM and IPM.

The past three seasons have seen a dramatic decline in the apparent importance of helicoverpa on the Darling Downs. While the proponents of AWM would like to claim responsibility for this reduced pest activity, the reality is that prevailing dry conditions have probably had most influence. From a positive perspective, the lower than normal helicoverpa activity has allowed pest managers to push the boundaries of pest management and experiment within their ‘comfort’ zone. Unfortunately the low pest pressure has led to some complacency and a perception that helicoverpa is no longer a problem. This is reinforced by the sentiment that growers feel they are now in a much better position to manage an outbreak year compared to five to 10 years ago. The RD&E activities have supported knowledge flow and assisted confidence building and
IPM adoption.

Several new tools and tactics were evaluated during the project:

1. Formulations of Bt were evaluated for selective management of armyworms, *Mythimna convecta*, in winter cereals. There was no difference between Bt aizawai and Bt kurstaki, and both products were inferior (about 45% mortality) compared to the standard pyrethroid.

2. Trichogramma and NPV were evaluated against helicoverpa in vegetative maize and sorghum. Vegetative summer cereal crops have been identified as potentially contributing to the build up of *H. armigera* populations through early summer. Trichogramma populations were established with releases from mid-November to mid-December, resulting in parasitism levels of 60–90% within 30 days of release (2–3 generations). This level of parasitism was significantly higher than levels recorded in nearby crops that had no parasitoid releases (0–30%). The use of NPV (applied by ground, EC, 80L water) against populations of first and second instar larvae in vegetative crops was not effective. The application of NPV to vegetative crops requires further investigation.

Following its timely application to grain sorghum, NPV is rapidly acquired by larvae. There was no significant difference in NPV infection levels 1, 2, 4, 6, 24, 48 and 96 hours after NPV application. The data supported recommendations to apply NPV when environmental conditions will provide best spray coverage.

A range of food sprays were evaluated to determine their ability to influence movement of predators in crops. Four commercially available food sprays were evaluated for their ability to attract natural enemies from a source crop (sunflower) to a neighbouring crop (seedling cotton). The food sprays evaluated were PredFeed®*, Mobait®*, Coat-on® and AminoFeed®*. At recommended rates, none of the products increased natural enemy abundance in seedling cotton. The only significant difference in insect populations detected was an increase in whitefly numbers in all treatments.

Local sources of natural enemies – roadside verges:
A roadside verge centrally located in the Brookstead cropping region was sampled monthly from November to January. The sampling was halted in January when the vegetation was severely affected by water stress. The sampling area was characterised by grasses and broadleaf plants which passed from vegetative to reproductive during the sampling. The most abundant predators across all sites were ants. Although microhymenoptera were abundant (including Trichogrammatids), no common helicoverpa parasitoids were identified. Predatory bugs and beetles were present in low numbers early in the sampling. Pitfall traps captured predatory carabid beetles.

Damage thresholds for chickpeas:
Three randomised, small plot cage trials were conducted to quantify the amount of damage and yield loss caused by helicoverpa larvae to flowering and pod filling chickpeas. Results indicate that a density in excess of the current threshold (2–4 larvae/m) can be tolerated in flowering and pod filling chickpeas without any significant yield loss. Further work is needed to accurately calculate the food consumption per larva as the basis for establishing precise thresholds. Until this work is done the current threshold recommendations will not be changed. The impact of moisture stress on the compensatory potential of the crops and the relationship with helicoverpa damage could not be assessed. This area of work is high priority for growers and agronomists.

Monitoring western flower thrip:
Western flower thrip (WFT) has been detected in late season cotton over a number of seasons. In the 2002–3 season, an extensive survey of cotton crops (as an indicator crop) was done from Nov–Mar to determine whether there were established populations of WFT in broadacre field crops. WFT were detected at almost all sites in very low numbers, particularly towards the end of the season. There was no evidence that these populations are building up in density and pose a threat to seedling crops.

Video analysis of predators of large helicoverpa larvae (prepupae) in maize, mungbeans, sorghum and cotton revealed a suite of both vertebrate and invertebrate predators. Mice were universally present at trial locations and caused high mortality of tethered prey. Mice may have a much greater influence on helicoverpa populations than first thought.

*H. armigera* culture has been maintained in support of the local and national research effort. Collaboration with The University of Queensland (UQ) School of Life Sciences has a) assisted developments with the DNA microsatellite markers for *H. armigera* in providing some understanding of movement and population genetics, b) supported the development of DNA
diagnostics for *H. armigera/H. punctigera*, Trichogramma, NPV, Microplitis and Ascovirus, and c) assisted with the understanding of ascovirus.

In addition to continuing support for the improved performance and adoption of NPV, project staff collaborated with agrochemical companies to deliver new products for helicoverpa management in grain crops. Steward® (indoxacarb®) by DuPont was registered on chickpeas, mungbeans and soybeans in 2002, and Tracer® (spinosad®) by Dow AgroSciences was registered on chickpeas, pulses, soybeans and sorghum in September 2004. Resistance management is a critical aspect related to the more widespread use of these new insecticides and project staff have worked closely with the Transgenic and Insect Management Strategies (TIMS) Committee to formulate a farming systems IRMS that meets the needs of both grain and cotton growers.

A major component of this project has been its development and extension activities – delivering information to our stakeholders and clients. A monthly publication of the ‘Heliothis Hotline’ and a biannual publication of the ‘Heliothis Stateline’ have been maintained. Four brochures on pest management topics are nearing completion and project staff have contributed to updates of the Department of Primary Industries and Fisheries (DPI&F) Summer and Winter Crop Management Notes. They have been actively involved in GRDC Grower and Adviser Updates, the IRMS Roadshow, AWM/IPM group meetings, IPM Forums, annual IPM evaluation and planning meetings, Agribusiness meetings and conferences (Maize, Cotton 2002 and 2004, ICE2004). Staff have contributed to, and assisted with the delivery of, training courses such as the Mungbean and Chickpea Accreditation courses and the cotton IPM short course. Additional courses are being planned in collaboration with Pulse Australia. Linkages for RD&E personnel were strengthened by participation in the annual project planning and evaluation meeting.

In June 2004 a national Helicoverpa Workshop was convened. The objectives of the workshop were to:

1. Review the developments in R,D&E related to helicoverpa management in Australia since the last workshop.
2. Review the role of extension in the development and implementation of AWM programs by growers in north-east Australia.
3. Examine the prospects for successful AWM, and
4. Provide direction for future R,D&E requirements for these pests.

A detailed workshop report was completed and distributed to participants and interested stakeholders.

**Other research**

In the course of this project staff have actively collaborated with other scientists/institutions. Some key linkages with respect to helicoverpa RD&E were:

- UQ, School of Life Sciences – Dr Kirsten Scott with DNA microsatellite technology and understanding movement of *H. armigera*; Dr Leanne Heslin with DNA diagnostics for species identification, parasitism and disease identification; and Dr Ian Newton with the project on ascovirus
- CSIRO – Dr Terry Hanzlik with the evaluation of stunt virus against *H. armigera* in grain sorghum
- Australian Cotton CRC – various RD&E staff in a coordinated AWM/IPM effort, and Scott Johnston in the development of databases and their interrogation for helicoverpa activity and pesticide use
- Various agrochemical companies in the development and placement of new products for helicoverpa management and their impact on beneficials

**Additional information**

List of Publications:


