Regional Management of Heliothis on the Darling Downs

DAQ85C

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REPORTS

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

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Part 3 – Final Report Format

1. PROJECT BACKGROUND

The 1997-98 cropping season in southern Queensland was characterised by a severe, sustained and damaging outbreak of *H. armigera*. This situation arose as a result of a combination of factors. *Helicoverpa* attacks most of the crops grown in the Darling Downs agroecosystem, and successive generations can occur where seasonal conditions are favourable, and control poor, or ineffective. There is a high dependence on insecticides for the management of heliothis in all crops. This over-reliance on insecticides has led to declining efficacy of registered insecticides because of resistance in *H. armigera*, resulting in more frequent field control failures, increasing pest densities, and increasing costs of control.

The impact of the 1997-98 season on the economic viability of most crops resulted in a widespread realisation within the farming community that a change in the current approach to heliothis management was needed to ensure a farming future in this region. Under greatest threat was the grains industry because it is highly dependent on 'old' compounds for heliothis management (eg. carbamates). There were also increasing concerns about environmental and human health hazards associated with increasing insecticide use.

In 1998-99 this project was initiated to develop a regional management approach for heliothis on the Downs. Reflecting the mixed cropping system of the region, the project was jointly funded by the GRDC and CRDC. After consultation with growers, consultants, researchers and funding bodies, two pilot study areas were defined, and a draft strategy developed. The two study areas were on the Jimbour floodplain and the other between Brookstead and Cecil Plains. The Jimbour floodplain area is predominantly a dryland grain production region with smaller areas of dryland and irrigated cotton. The Brookstead-Cecil Plains area produces predominantly irrigated cotton and grains with smaller areas of dryland grain crops and cotton. Strong local support for the project was expressed at initial grower meetings in each of the areas.

The regional management strategy for *H. armigera* is based on the theory that it is a local, and recycling, population of the pest that drives the spring-summer build up in pressure. A strategy that targets bottlenecks in the population development will result in a reduction of the overall *H. armigera* population, reducing pest densities and the frequency with which chemical control is required. Flowing on from the lowered pest pressure and reduced insecticide use would be a reduction in the level of insecticide resistance in the population, and consequently greater opportunity for the use of biological insecticides (eg. Bt and NPV), and other IPM options.

The strategy was implemented abased on three main components that aimed to reduce (1) the survival of overwintering, insecticide-resistant *H. armigera* pupae, (2) the early season buildup of *Helicoverpa* on a regional/district scale, and (3) the mid-season population pressure on *Helicoverpa*-susceptible crops. The implementation of the strategy was to be achieved through the participation of growers and their advisers in the study areas.

A research and extension program was designed to support and evaluate the implementation and impact of the regional management strategy. In conjunction, a number of associated projects (eg. spatial analysis, DNA microsatellite studies) were supported by the collection of data and material from the study areas to answer specific questions relating to the strategy.

2. PROJECT OBJECTIVES AND ACHIEVEMENTS.

Project objective:

To develop a regional approach for the management of Helicoverpa spp. on the Darling Downs, and monitor its implementation and effectiveness.

- Develop and evaluate spring trap cropping and additional tools for inclusion in the regional management strategy
- Determine the relative contribution of grain crops to the regional heliothis population.
- Maintain communication within the pilot study areas, in relation to project progress, as well as general farmer discussion and learning. Communicate with industry and stakeholders through formal reporting, presentations at workshops, seminars and conferences, and through the media.
- Assess the impact of HRMS on the local heliothis population, and the grower community.

Project achievements:

The key project achievement has been to secure, and maintain, a high level of grower and consultant involvement in the Heliothis Regional Management Strategy (HRMS) project. At the conclusion of the project, growers in both study areas continue to implement the recommendations of the Strategy. Components of the Strategy, such as spring trap cropping and pupae busting have been adopted, as an integral part of the farming activities, on the majority of farms in the study areas. The perceived success of the strategy, and particularly of spring trap cropping, has resulted in widespread adoption beyond the pilot study areas. It has also spawned a large number of groups, implementing in one form or another, a regionally focussed heliothis management strategy (39 groups at July 2001) across cotton and mixed-cropping regions of southern Qld and northern NSW. This achievement is a result of the supportive extension program of regular group meetings and discussion, newsletters and technical information made available through DAQ85C. The extension effort has extended beyond the immediate study areas through information in the media, the *Heliothis Hotline* and *Heliothis Stateline* newsletters and participation in research updates for growers and consultants in the northern region.

The 1999-2000 and 2000-01 seasons have been characterised by low to very low heliothis pressure by historical standards. The contribution that the HRMS has made to the lower pressure is difficult to partition relative to the impact of the unusually dry winter and spring experienced in southern Queensland in these seasons. However, involvement in the HRMS project, and the low heliothis pressure, has given many growers confidence to experiment with alternative management options that were previously thought non-viable in an environment of high and sustained heliothis pressure. The change in grower attitude to heliothis management, and insect pest management in general, as a result of involvement in DAQ85C has been dramatic. The assessment of the project team is that for many of these growers the change in approach to heliothis management will persist even in an environment of higher heliothis pressure.

Research has clarified the relative contribution of grain and cotton crops to the local heliothis population during the seasons. As a result, the assumption that grain crops, with the exception of chickpea, are major sources of heliothis has been challenged. The introduction of NPV (Gemstar®), particularly into sorghum, has elevated the natural incidence of NPV across the study regions. As a consequence, many of the grain crops previously considered nurseries for heliothis, are now proving to be valuable sinks for heliothis, and potentially nurseries for parasitoids and predators (natural enemies) that thrive in grain crops in the absence of disruptive, broad-spectrum chemistry. This understanding of the role of different crops in the generation of heliothis populations is fundamental to the development of a farming-systems approach to the management of heliothis.

Components of the HRMS have been trialed and evaluated, in particular spring trap cropping. The research has demonstrated that the recommended sowing date (late July-early August), is appropriate for the Downs to get trap crops flowering when *H. armigera* are emerging from winter diapause. Trials have also demonstrated that, in comparison with a range of other spring-flowering crops, chickpea is the most suitable trap crop option in this environment. Chickpeas are agronomically robust, flowering time can be manipulated by slashing, making it suitable for both irrigated and dryland conditions, and heliothis larval densities are generally higher in chickpea than in other crops trialed.

More difficult has been the evaluation of the impact of the HRMS on the local heliothis population, and this objective still needs some consideration. In the absence of established techniques for determining the impact of regional management, three indicators were identified as providing some indication of impact: (a) lower pressure in the pilot study areas relative to areas not implementing HRMS, (b) a delay in the buildup of the local population during the season, compared with the 1997-98 season, and (c) a decrease in the level of insecticide resistance in the local, study area populations of *H. armigera*.

The adoption of spring trap cropping across all cotton-growing regions has meant there was no 'control' region with which heliothis pressure in the pilot study areas could be compared. Heliothis pressure was generally lower across all cotton-growing regions in the 99-00 and 00-01 seasons, suggestive of climatic conditions having a greater impact on local populations than HRMS. The 99-00 and 00-01 seasons have seen a progressive delay in the time to peak heliothis pressure in the pilot study areas, compared with the 98-99 season. However, partitioning the impact of HRMS activities from the impact of extremely dry spring conditions has not been possible. Anecdotal information from growers, and pesticide application records, indicate that heliothis outbreaks in crops have been 'easier' to control with insecticides. Records from growers show a decrease in the

number of chemical mixes, and the number of control failures. Again it is difficult to partition the contribution of HRMS from that of overall lower pest pressure, improvements in application and timing
Based on sound theory, spring trap cropping will be retained in any future HRMS. Direct evidence of a difference in insecticide resistance profiles between the pilot study areas and the rest of the Downs is not available because of the way the resistance testing uses pooled samples from across the Downs, combining sites within and outside the study areas.

DAQ85C has important links with the spatial and temporal analysis project "Heliothis migration and pest management: Effects of movements within and between cropping regions". The analysis of data collected by the regional management project and analysed by Dr Wayne Rochester, University of Queensland, has provided support to several assumptions that underpin the current regional management strategy. These are (a) that within the study areas the *H. armigera* population is locally generated; (b) that chickpea is potentially a major source of heliothis invading summer crops; and (c) that cotton is the major contributor to the local heliothis population from mid January onwards. These findings have contributed to the formulation of research strategies to further develop and refine the existing regional management strategy.

Project outputs:

Technical information in the form of brochures, newsletters and general media releases, has been the key outputs of the project. These outputs are designed in increase the level of grower knowledge and understanding of heliothis biology and ecology. With the introduction of HRMS, and IPM, pest management is becoming more complex for growers and their advisers. In this context, management decisions can only be made with some understanding of the biological system and its interactions. Examples of project outputs are included in the list of publications arising from the project.

Industry benefits:

Adoption of the basic HRMS has been widespread both within and beyond the study areas, in both the grain and cotton industries. The direct impact of the tactics, such as spring trap cropping, pupae busting and improved heliothis management in grain crops, is difficult to quantify in terms of pest pressure or dollars. However, in qualitative terms, the introduction of a 'new' approach to heliothis management has had a dramatic impact on attitude, and to some extent practice, of pest management in both the grains and cotton industries over the past 2-3 years. The change in attitude has significant benefits for the industries because it is driving a movement away from an unquestioning reliance on insecticides, towards the implementation of integrated pest management (IPM). With the reduction in heliothis pressure expected as a result of continuing widespread adoption of the HRMS, it is probable that more regions will see the benefits from a change in approach to heliothis management.

The benefits of this change in approach to pest management will be seen in potential financial savings to growers both from reduced insecticide use, and/or reduced crop losses. There are substantial benefits to the health of individual growers and their families, as well as to the environment of reduced use of broadspectrum insecticides. The perception of consumers towards the industry as a result of an ability to demonstrate a reduction in the use of pesticides, and particularly the 'old' chemistry is another area the industries can potentially exploit in marketing and promotion of products.

Other benefits:

One of the major flow-on benefits of the project, as described by grower participants, has been the opportunity for increased grower to grower communication within the groups that meet regularly. In the group environment, grain and cotton growers are talking each other about their different approaches to heliothis management, their basic pest management philosophies and aspirations.

The HRMS has given growers a framework within which to talk about their pest management issues. As a group, those involved are very proud of their achievement in terms of reduced costs, reduced insecticide use, greater awareness of natural enemies which they associate, to some extent, with being involved in the project. The change in pest management within the farming community is something of which they want the wider community to be aware, and this was the catalyst for the Heliothis Working Group video project (see list of publications).

3. RELEVANCE OF RESEARCH TO THE CORPORATION'S THREE OUTPUTS

The HRMS has relevance to the sustainability and people and community outputs of the Corporation. Successful implementation of the HRMS, resulting in lower heliothis pressure and lower levels of insecticide resistance, contribute directly to the sustainability of cotton production. Sustainability in terms of profitability, as a result of reduced reliance on, and use of, insecticides. Increased reliance on the contribution of natural enemies, cultural control (eg. trap crops) and biopesticides will impact on the farming system and its natural resource base. Therefore, sustainability in terms of the environment as a result of reduced insecticide use, and substitution of broadspectrum insecticides with biological products and pest-specific products. Flow-on benefits accrue also for the growers, farm workers, farm families and the rural community exposed to insecticides used on-farm.

Involvement in the HRMS is delivering benefits to participants and the farming communities involved. In each of the pilot study areas there is a number of small groups of neighbouring growers. Involvement in groups has been instrumental in developing a regional mindset in relation to the management of heliothis. The realisation that the management of heliothis is a community issue has fostered a high level of cooperation within groups. In addition, the regular group meetings have provided a forum in which growers are able to discuss with each other a range of issues, experiences and perceptions about pest management and other farm management issues. The sharing of experiences and ideas through group discussion has been the catalyst for resolution of some neighbourhood hostilities resulting from a lack of understanding of how particular practices were impacting on neighbours. Many growers have said that these groups have provided them with an opportunity to talk to neighbours, and for cotton growers to talk with grain growers, in an environment that has not existed for some time with the demise of many community social events.

4. RESEARCH REPORT

RESEARCH COMPONENTS

The following are the research and development components of the HRMS project that comprised the means to achieve the project objective. Each component is presented separately including recommendations/conclusions, material and methods and results.

1. Develop and evaluate spring trap cropping and additional tools for inclusion in the regional management strategy.
2. Determine the relative contribution of grain crops to the regional heliothis population.
3. Maintain communication within the pilot study areas, in relation to project progress, as well as general farmer discussion and learning. Communicate with industry and stakeholders through formal reporting, presentations at workshops, seminars and conferences, and through the media.
4. Assess the impact of HRMS on the local heliothis population, and the grower community.

4.1 Development and evaluation of spring trap crops

The draft HRMS recommended the planting of chickpea trap crops, in late July-early August, to be attractive at the time of *H. armigera* emergence from winter diapause in October-November. Aspects of trap cropping that required examination were (a) the effectiveness/attractiveness of chickpea as the spring trap crop, (b) the appropriateness of the suggested planting time given the potential for variation in the timing of emergence from diapause between seasons and (c) the potential to manipulate trap crops to accommodate planting opportunities in a dryland situation, or delayed emergence from diapause.

A. EFFECTIVENESS OF CHICKPEA AS THE SPRING TRAP CROP SPECIES

Conclusions:

Comparison trials of different potential trap crop species, over two seasons, have supported the recommendation of chickpea as the preferred spring trap crop species on the Downs.

In each of the two trials attractiveness was measured in terms of larval abundance. Alternatively, attractiveness could be measured in terms of egg density ie. attractiveness to ovipositing females. Larval density may be a measure of the survival of eggs and larvae to on the target plants, rather than purely attractiveness for oviposition. This aspect of trap crops warrants some consideration.

Trap crop species comparison (1999)

SUMMARY

The primary aim of the spring trap cropping program is to attract and destroy as many *H. armigera* as possible in relatively small areas of trap crops (approx 1% of the cultivated area in the study sites). In this trial, chickpea proved to hosted significantly more heliothis larvae than any of the other crops trialed. In addition, chickpea flowering coincided with the period of peak *H. armigera* emergence from diapause, whilst the majority of the other crops matured earlier. Chickpea also hosted the lowest number of potential non-heliothis pests (green mirid, green vegetable bug and apple dimpling bug) of the crops trialed.

As a source of beneficial insects, that may subsequently move into other crops in the farming system, chickpea performed poorly. Other crops hosted large numbers of generalist, and aphid predators and parasitoids. Principally, these beneficial species were present in response to large populations of aphids on canola, fieldpea, niger and canary.

The benefits of using chickpea as a spring trap crop, with the specific purpose of attracting the maximum number of *H. armigera*, cannot be matched by the other crop species trialed. There are a number of factors that contribute to the recommendation that chickpeas should continue to be used as a spring trap crop in an area-wide management context

- agronomic suitability of chickpea in moisture limited conditions (such as often exist in dryland situations),
- the timing of flowering to coincide with *H. armigera* emergence from diapause,
- the high level of attractiveness to heliothis, and
- the poor suitability of chickpea for non-heliothis pests.

INTRODUCTION

One of the key components of the strategy for the area-wide management of heliothis (AWM) is spring trap cropping. Initial recommendations are to sow a chickpea trap crop in late July – early August, the aim being to have the crops flowering in October-November, the period of *H. armigera* emergence from diapause.

With the appearance of *Ascochyta rabei* in chickpea crops in Queensland, there are concerns that spring trap crops may represent a source of inoculum in the farming system. The perception of many commercial chickpea growers is that using chickpea as a spring trap crop is potentially a threat to subsequent or neighbouring crops. In response to these concerns it was considered warranted to investigate whether there was a viable alternative species suitable for spring trap cropping.

Chickpea is considered a very poor host for beneficial insect species, predators and parasitoids. Therefore, their potential contribution to the beneficial population in the farming system, early in the season, is considered negligible. It has been proposed that a spring trap crop which also generated good numbers of beneficials, would be preferable to chickpea.

To address these two issues, field trials were established using a range of spring-flowering crop species.

MATERIALS AND METHODS

Two replicated field trials were sown on 5 and 6 August, at sites near Jimbour and Brookstead on the Darling Downs. Species included in the trial are detailed in Table 1. A Latin Square design was used with six replications of each crop. Each plot was 20m long by 9 rows (Brookstead) or 12 rows (Jimbour) wide, on 0.75m row spacing. Both sites were prepared with 100 units of nitrogen. Inoculant and fungicide were applied with the pulses (chickpea and fieldpea). Both sites were dryland, without prewatering, or irrigation for the duration of the trial.

Table 1. Crop and varieties included in spring trap crop comparison trials, Jimbour and Brookstead 1999.

Crop (variety)
Chickpea (Norwin)
Fieldpea (Dunfield)
Linseed
Canola (Oscar)
Niger (Forrest)
Canary

Plots were sampled for heliothis using a beat sheet to sample two metres of row. Each plot was sampled three times to give a total of 6m of row sampled per plot.

A suction machine was used to sample for non-heliothis insects in the plots. Twenty metres of row was sampled from each plot, and replications of each variety pooled. Heliothis density samples were taken on two occasions, 13 October and 3 November. Assessments of beneficial numbers were made on 9 September, 21 September, 8 October, 22 October and 3 November. Heliothis larvae collected during sampling were placed on diet and reared in the laboratory to assess level of parasitism, disease and species.

Heliothis density data was analysed using ANOVA for Latin Square (Genstat 5 v. 4.1).

The Brookstead trial was sampled for heliothis during the period of *H. armigera* emergence from diapause, as predicted using the emergence model and current temperature data (Figure 1).

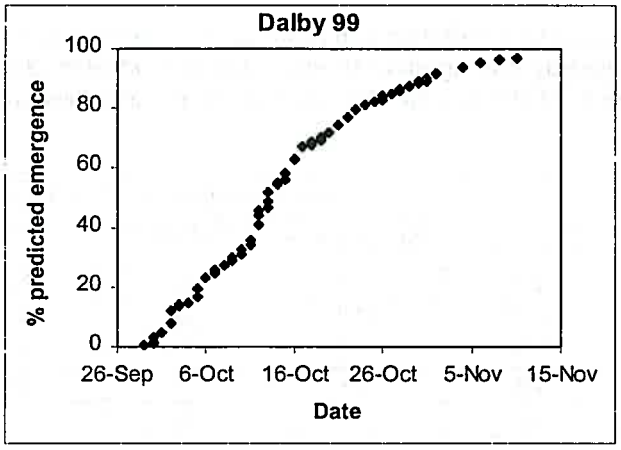

Figure 1. Predicted rate of emergence 1999-00 season, based on actual temperatures recorded at Dalby.

RESULTS AND DISCUSSION

The trial at Jimbour failed by mid-September as a result of the extremely dry conditions that persisted through August and September. No meaningful comparisons were possible at this site. Therefore, only the results of the Brookstead trial are reported on here.

Attractiveness to heliothis

Sampling only considered larval, and not egg density, therefore it is perhaps measuring survival rather than attractiveness in relation to oviposition. This is an aspect that should perhaps be pursued in further work on trap crops.

The density of larvae on chickpea was significantly higher than on any of the other crops trialed on both sampling occasions (Table 2). Under the limited water conditions of the trial, most of the crops trialed, with the exception of chickpea and canary, matured before the period of peak *H. armigera* emergence from diapause.

Table 2. Mean heliothis density (per 2m row) in a range of spring-flowering crops, assessed for potential as spring trap crops for heliothis.

Mean number of heliothis larvae per 2m sample					
13 October, 1999			3 November, 1999		
Treatment	Mean	Crop Phenology	Treatment	Mean	Crop Phenology
Niger	0.22 a	Flowering	Canary	0.00 a	Boot-flower
Canola	0.33 a	Flower-pod set	Niger	0.33 ab	Flower – seed set
Linseed	1.05 ab	Bud – flower	Linseed	0.83 ab	Flower-boll set
Canary	1.47 b	Vegetative	Fieldpea	0.94 ab	Pod fill
Fieldpea	1.72 b	Pod fill	Canola	1.00 b	Flower-pod set
Chickpea	4.00 c	Bud – first flower	Chickpea	14.32 c	Flower-pod set
l.s.d	0.938		l.s.d	0.975	

Parasitism, disease and species composition

Levels of parasitism and disease were generally low, particularly in chickpea. *Microplitis* and *Heteropelma* levels in fieldpea and canola were similar to levels found in a range of summer grain crops in the Brookstead area.

All crops in the trial attracted predominantly *H. armigera*, which is the species being targeted with spring trap crops.

Table 3. Level of parasitism, ascovirus infection and *H. armigera* in populations of heliothis larvae collected from potential spring trap crop species, 'Dunbar', Brookstead 1999. Data pooled from collections made on 13 October, 22 October and 3 November. No larval collections were made from canary.

Crop	No. larvae collected	Level of infection in larval population (%)					
		Microplitis	**Heteropelma**	Other wasps	Tachnids	Ascovirus	***H. armigera***
Chickpea	164	1.2	1.2	0	2.4	0.6	66
Fieldpea	58	20.7	12.1	0	0	1.7	75
Canola	34	17.6	14.7	5.8	0	2.9	87.5
Linseed	50	20	16	0	0	6	50
Niger	4	0	0	0	0	0	na

Other pest and beneficial species (Table 4)

In interpreting these results, it must be remembered that not all beneficial insects are active during the day when the sampling occurred, nor are they necessarily easily dislodged by a suction machine.

The density of non-heliothis pests was generally low across the trial, however significant numbers of green mirids (GM) were found in niger. Field pea hosted a relatively large number of green vegetable bugs (GVB). Of all the crops trialed, chickpeas hosted the lowest number of non-heliothis pest.

Chickpea also hosted the lowest number of beneficial insects of all the crops trialed. The most abundant beneficial species were primarily aphid feeders (lady beetles, lacewings, aphid parasitoids). The abundance of these species was associated with the crops which were moderately to heavily infested with aphids (canola, fieldpea, niger and canary).

CONCLUSIONS

The primary aim of the spring trap cropping program is to attract and destroy as many *H. armigera* as possible, in relatively small areas of trap crops (approx 1% of the cultivated area in the study sites). In this trial, chickpea proved to host significantly more heliothis larvae than any of the other crops trialed. In addition, chickpea flowering coincided with the period of peak *H. armigera* emergence from diapause, whilst the majority of the other crops matured earlier. Chickpea also hosted the lowest number of potential non-heliothis pests (green mirid, green vegetable bug and apple dimpling bug) of the crops trialed.

As a source of beneficial insects, that may subsequently move into other crops in the farming system, chickpea performed poorly. Other crops hosted large numbers of generalist, and aphid predators and parasitoid. Principally, these beneficial species were present in response to large populations of aphids on canola, fieldpea, niger and canary.

The benefits of using chickpea as a spring trap crop, with the specific purpose of attracting the maximum number of *H. armigera*, cannot be matched by the other crop species trialed. The agronomic suitability of chickpea in moisture limited conditions (such as often exist in dryland situations), the timing of flowering, the high level of attractiveness and the absence of non-heliothis pests all contribute to the recommendation that chickpeas should continue to be used as a spring trap crop in an area-wide management context.

The issue of ascochyta management is being addressed through education of trap crop growers who are not necessarily commercial chickpea growers. It is considered that with good management, chickpea trap crops pose no more threat to the commercial chickpea crop than other commercial chickpea crops.

Chickpea variety comparison (2000)

SUMMARY

No significant difference was found between the attractiveness of desi and kabuli varieties of chickpeas to heliothis. The recommendation for spring trap crops remains to plant a locally adapted desi variety. Seasonal conditions did not allow an assessment of the advantage of ascochyta resistance to attractiveness, but under the trial conditions there was no difference in the attractiveness of the commercial varieties and the ascochyta resistant parental lines to heliothis.

Although some of the alternative legume species trialed show some potential as hosts for a range of beneficial insects, their lower level of attractiveness to heliothis makes them less suitable as spring trap crops in an area-wide management context. However, many of the pasture species trialed did not establish well with the August planting. Further work may be warranted with such species with an autumn planting.

INTRODUCTION

Both desi and kabuli chickpea varieties have been used over several seasons as spring trap crops for *Helicoverpa armigera*, as component of the area-wide management trial conducted on the Darling Downs. Chickpeas were selected as the trap crop species because they are widely reputed to be highly attractive to heliothis in a vegetative as well as flowering stages of development. In addition, trial work has shown that with chickpea, the period of attractiveness can be manipulated by slashing. These attributes, combined with a good level of tolerance to low moisture has made chickpeas and effective trap crop for this application in both irrigated and dryland situations.

However, there are a couple of issues with using chickpeas that are have required attention. First, the rapid spread of *Ascochyta rabei* across the Darling Downs has resulted in the use of spring trap crops being

considered a potential source of innoculum for commercial chickpea crops. Considerable effort has been put into producing extension material for growers that clearly outlines the management needed for chickpea trap crops to prevent the development and spread of ascochyta. Second, chickpea is a notoriously hostile environment for most insect species other than heliothis. This means that the potential for chickpea trap crops to contribute beneficial insects (predators and parasitoids) to the farming system is negligible.

It was determined that these two issues warranted investigation, and this trial represents the second year of trials to assess the potential of alternative trap crop species. The comparison between desi and kabuli varieties is pursued because there is substantial anecdotal information that suggests kabuli varieties are more attractive to heliothis. If this is the case, then the use of kabuli varieties may be warranted to maximise the effectiveness of the spring trap crops.

The perennial pasture species included in the trial are currently undergoing assessment by the QDPI pasture group. A range of spring-flowering species is included in this trial. It was thought that one, or more of these species, may provide a more manageable alternative to lucerne in a rotational cropping system. Lucerne known to be attractive to heliothis and to support a wide range of beneficial insects, but the difficulties commonly encountered with establishment, watering and eradication make it unsuitable for a short-term trap crop.

TRIAL AIMS

- To determine whether Kabuli varieties of chickpea are more attractive to heliothis than desi varieties.
- To test the attractiveness of ascochyta-resistant parental lines to heliothis.
- To test the attractiveness of a range of pasture species to heliothis.
- To determine the potential of the species trialed to support populations of secondary pests or beneficial species.

MATERIALS AND METHODS

Five chickpeas and one vetch were sown in a replicated, latin square design, with six replicates. Each plot was four rows wide by 10 metres long. The pasture species were sown in small plots of varying length, depending on the amount of seed available, the range was from 5 to 20 m of a single row.

Additional plots (4 rows x 20m) of lentil, field pea, sunflower and sorghum were sown alongside the replicated trial. The aim of this sowing was to determine the species composition (between *H. armigera* and *H. punctigera*) of populations on the legume species, and to identify whether they were potentially hosts for other pests and/or beneficial insect species.
The varieties sown in the trial are shown in Table 4.

All varieties were sown using a cone seeder on 7 August, 2000. Chickpeas and pasture species were inoculated with the appropriate inoculum. Chickpea seed was treated with a fungicide seed dressing (P-Pickle T).

The trial was monitored from emergence for heliothis larvae, and sampled through the period which generally coincides with the emergence of *H. armigera* from diapause (Oct-Nov). Three metres of row were sampled from each plot to determine the larval density. No attempt was made to assess egg numbers. Plants in the three metres of row (3 x 1m row) were cut at ground level, placed in paper bags, and returned to the lab where the larval count was made. To assess numbers of non-heliothis species, 20m of row of each variety was sampled with a suction sample machine. Where pasture plots were less than 20m in length, the entire plot was sampled.

Larvae collected on each sampling occasion were placed on diet and reared in the laboratory to determine species and level of parasitism and disease.

Pheromone traps operated in the Brookstead area to provide an indication of the timing of emergence from diapause, and the timing and size of *H. punctigera* immigration.

Data was analysed using ANOVA for Latin Square (Genstat 5, v 4.1).

Table 4. Varieties and species sown in the alternative trap crop comparison trial, "Anchorfield", August 2000.

Chickpea	**Desi varieties** Jimbour Amethyst ICC3996 (ascocyta resistant line)[ϕ]
	Kabuli varieties Bumper FLP94-746C (ascocyta resistant line) [ϕ]
Vetch	Namoi (forage variety)
Sunflower	***Hysun 25 (early)***
Lentil	***Cobber***
Field pea	***Dundale***
Sorghum	***MR Goldrush (quick)*** ***MR 31 (med quick)*** ***Buster MR (medium)***
Pasture species	**Hedysarum carnosum** *Hedysarum coranarium* *Hymenocarpus circinnatus* *Lotus orni* *Tetragonolobus palestinus* *Trifolium alexandrinum* *Trifolium pauciflorum* *Trifolium vesiculosum* *Scorpiurus muricatus*

[ϕ] Ascochyta-resistant parental breeding lines from the Victorian Institute for Dryland Agriculture chickpea breeding program

RESULTS AND DISCUSSION

Spring heliothis activity

H. punctigera activity in the spring of 2000, was high relative to the previous two seasons. Emergence from diapause occurred earlier than average as a result of a week of higher than average temperatures in late September (Figure 2).

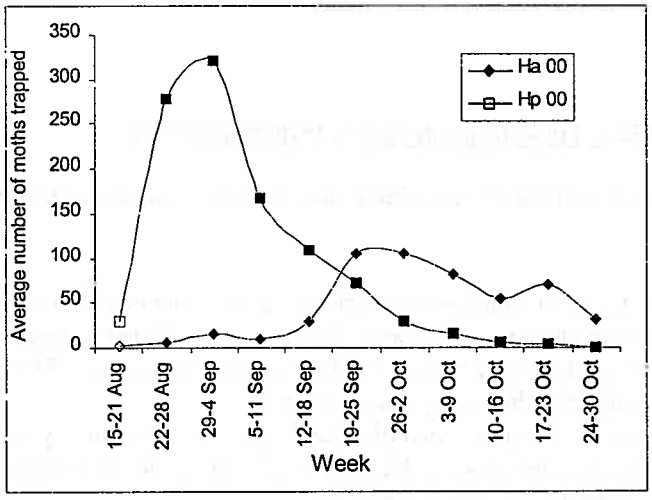

Figure 2. Heliothis activity for spring 2000, recorded in the Brookstead area (average of 5 pheromone traps).

Attractiveness of kabuli, desi chickpeas and vetch to heliothis

There was no consistent, significant difference in the number of larvae on desi and kabuli varieties in the trial, even though there was variation in the ranking of the varieties amongst dates. The desi varieties flowered earlier than the kabuli varieties which may have contributed to the high larval numbers on Amethyst in the first sample (Table 5).

There was no difference in attractiveness of the ascochyta blight resistant varieties and commercial varieties trialed.

Vetch consistently recorded the lowest number of larvae, significantly less than found on the chickpea varieties, except on the final sampling date (22 Nov) when there was no difference between vetch and chickpea varieties.

Table 5. Mean larval density (per 3 m row) on different varieties of chickpea and Namoi vetch on each of four sampling occasions. Means in the same column not followed by the same letter are significantly different ($P<0.05$). Comparison only possible between varieties on individual sampling dates, not across dates.

5 October		18 October		2 November		22 November	
Variety	Mean no. larvae	Variety	Mean no. larvae	Variety	Mean no. larvae	Variety	Mean no. larvae
Namoi (vetch)	0 a	Namoi (vetch)	0.2 a	Namoi (vetch)	0.5 a	Bumper	15.8 a
Bumper (kabuli)	8.6 b	Bumper	15.5 b	Amethyst	36.0 b	FLP94-746C (AB$^{\phi}$ kabuli)	22.0 ab
FLP94-746C (AB$^{\phi}$ kabuli)	11.5 b	FLP94-746C (AB$^{\phi}$ kabuli)	15.5 b	Jimbour	37.5 b	Jimbour	23.4 ab
Jimbour (desi)	13.9 bc	Amethyst	18.3 b	Bumper	44.2 bc	Namoi (vetch)	25.0 ab
ICC3996 (AB$^{\phi}$ desi)	14.3 bc	ICC3996 (AB$^{\phi}$ desi)	20.8 b	FLP94-746C (AB$^{\phi}$ kabuli)	54.5 c	Amethyst	32.0 b
Amethyst (desi)	18.3 c	Jimbour	21.8 b	ICC3996 (AB$^{\phi}$ desi)	57.2 c	ICC3996 (AB$^{\phi}$ desi)	32.0 b
lsd	6.53	lsd	11.07	lsd	15.58	lsd	12.11

$^{\phi}$ Ascochyta-resistant parental breeding lines from the Victorian Institute for Dryland Agriculture chickpea breeding program.

Beneficial and pest insect profile of alternative trap crop species

A number of pest and beneficial species were hosted by the crop and pasture species included in the trial (Table 3). In summary:

- Green mirid was the most abundant secondary pest. Breeding populations were found in all crops sampled, with the exception of chickpea and wheat. Wheat in the local area was sampled for comparison with the broadleaf crops in the trial. The presence of breeding populations of GM is potentially problematic for neighbouring spring crops like mungbean and cotton.
- The pasture species (*Lotus*, *Tetragonolobus*) and vetch hosted relatively high numbers predatory bugs and beetles. The predatory bugs were predominantly *Geocoris lubra* (big eyed bug), and the predatory beetles predominantly ladybird species (Coccinellidae).
- The dense canopied pasture species such as vetch, *Tetragonolobus*, and *Lotus* are potentially good hosts for a range of beneficial insects and spiders. It may be worth trialing these species with a winter, rather than a spring planting to allow them to reach their potential in terms of biomass.

CONCLUSIONS

The recommendation for a preferred spring trap crop for heliothis is a locally adapted desi variety. This trial result demonstrates no advantage to using a kabuli type, and using desi types avoids the disease and cost disadvantages associated with kabuli types. It would be desirable to have an ascochyta resistant variety available for use as trap crops, and this trial result show that there is not likely to be any reduction in attractiveness of these lines, relative to current commercial varieties.

Although some of the alternative legume species trialed show some potential as hosts for a range of beneficial insects, their lower level of attractiveness to heliothis makes them less suitable as spring trap crops in an area-wide management context.

B. THE APPROPRIATENESS OF THE RECOMMENDED PLANTING TIME GIVEN THE POTENTIAL FOR VARIATION IN THE TIMING OF EMERGENCE FROM DIAPAUSE BETWEEN SEASONS

Conclusion:

The recommended late June – early July planting date for chickpea trap crops has resulted in trap crop flowering coinciding with the period of H. armigera *emergence from diapause in the last three seasons (1998, 1999, 2000). The recommendation for planting time, and the planting of chickpea, is appropriate for the Darling Downs.*

The model that enables the prediction of the rate of emergence from diapause has been demonstrated to be sufficiently accurate to be a useful tool in the management of chickpea trap crops to maximise their potential.

INTRODUCTION

The aim of the trap cropping program is to have the traps as attractive as possible (flowering) during the period of *H. armigera* emergence from diapause. Chickpea is highly attractive to heliothis at flowering, and has a relatively long flowering period of up to four weeks given adequate soil moisture. The timing and duration of *H. armigera* emergence from diapause is temperature driven, resulting in variation between years. However, emergence typically occurs through October for a period of approximately four weeks. The lengthy chickpea flowering period offers a significant advantage for trap cropping, making the coincidence of flowering and moth emergence more likely.

In the formulation of the draft HRMS a recommendation was made for the planting of chickpea trap crops based on an estimate phenological development of the crop. Over the past three seasons the development of trap crops and the timing of H. armigera emergence from diapause have been monitored to determine whether it is necessary to make any change to the recommended trap crop-planting window.

MATERIALS AND METHODS

A network of paired (*H. armigera* and *H. punctigera*) pheromone traps was established across each of the study areas in 1998, 1999 and 2000. In 1998 and 1999, ten sets of traps were monitored in each study area. In 2000, five sets of traps were monitored. Farmer cooperators monitored and counted moths on a daily basis. In the representation of the data, trap catches are averaged across all sets of traps in each study area and calculated on a weekly basis to minimise the 'noise', or variation, across the study areas.

The emergence model developed by David Murray and David Butler (QDPI) was used to predict the timing and rate of emergence from diapause, using current temperatures for each of the seasons. Difficulties with obtaining reliable temperature data for the Brookstead study area meant that the model has only been run for the Jimbour study area, using Dalby temperature data. The pattern of H. armigera activity, as recorded by the pheromone traps, provided a means of verifying the accuracy of the model.

Trap crop phenology was monitored regularly during the spring, in conjunction with monitoring of heliothis populations.

RESULTS AND DISCUSSION

In each of the three years of the project, the flowering of late June-early July planted chickpea trap crops coincided with the period of emergence of *H. armigera* from diapause (Fig 3). This result supports the recommendation to a) use chickpea as the trap crop species and b) plant in the late June-early July window. It is important to remember that these recommendations have been shown to be appropriate for the Darling Downs pilot study areas, and may not hold in other regions.

Peak moth activity occurred at around 50% predicted emergence. The predicted rate of emergence of the diapausing population occurs according to a normal distribution. Therefore, from the similarity in the pattern of moth activity recorded in the traps, and the predicted rate of emergence, it appears that the model is accurately predicting both the timing and rate of emergence from diapause (Fig 3). This result suggests that in the absence of pheromone trap information, the model is a useful tool for estimating the initiation of emergence from diapause, and has application in the management of trap crops to maximise their potential. For example, early populations of heliothis (likely *H. punctigera*) may warrant control in a trap crops if it appears that they may complete development and emerge before the majority of the *H. armigera* have emerged from diapause. Having some understanding of the timing of *H.armigera* emergence from diapause is critical in maximising the potential of spring trap crops.

The pheromone trap data, with a clear coincidence between predicted emergence from diapause and *H. armigera* activity in traps, supports the assertion that the *H. armigera* population is generated locally and is not resulting from substantial immigration events in spring. The assertion that the *H. armigera* population is generated locally is fundamental to the success of a regional management strategy that aims to reduce the size of the local population by minimising breeding and survival of the population at key bottlenecks ie. autumn (pupae busting) and spring (trap cropping).

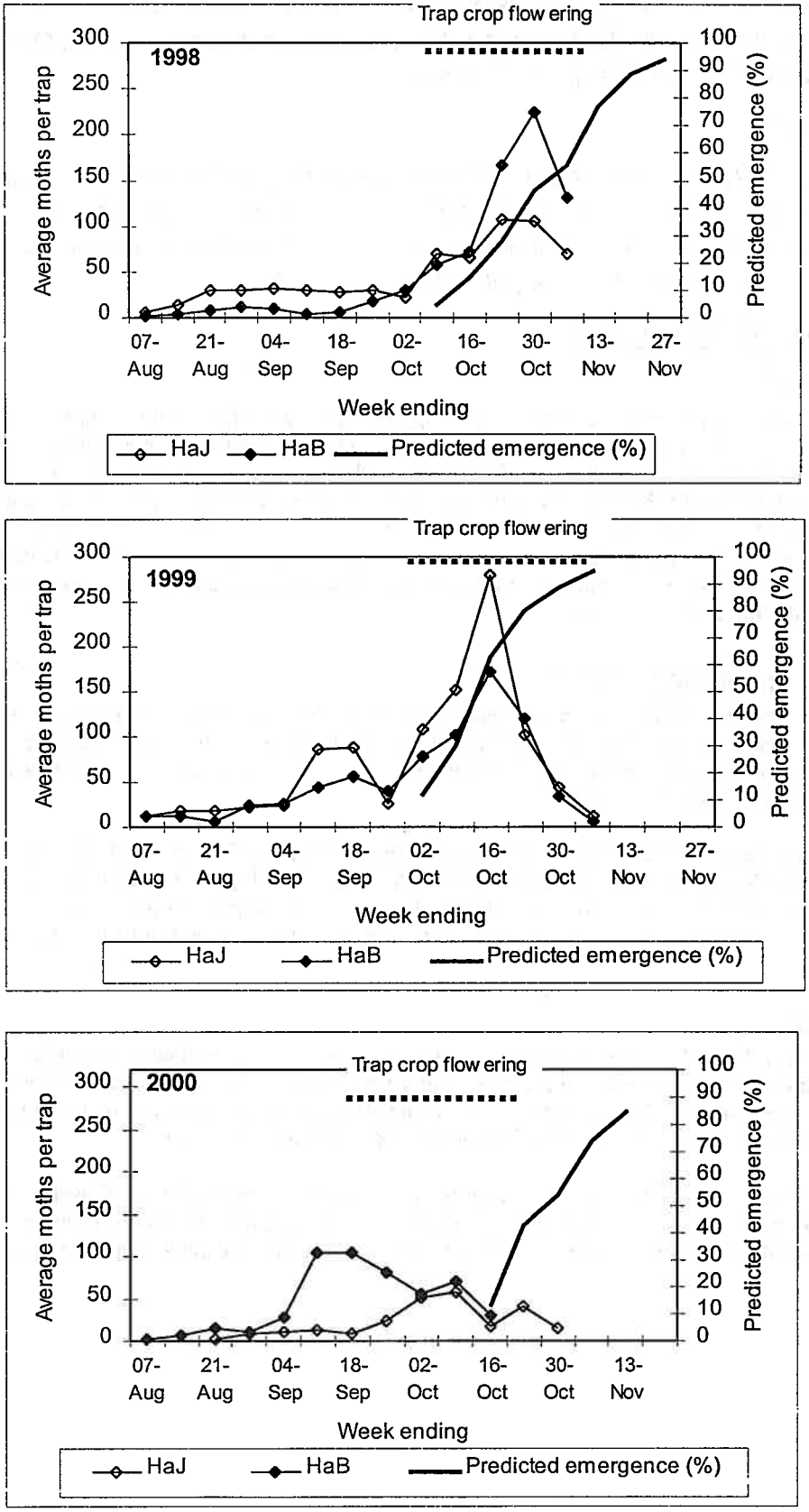

Figure 3. *Helicoverpa armigera* activity as determined by pheromone traps, and predicted rate of emergence for the 1998, 1999 and 2000 seasons, for each of the Heliothis Regional Management pilot study areas. HaJ = *H. armigera*, Jimbour study area; HaB = *H. armigera*, Brookstead-Cecil Plains study area.

C. THE POTENTIAL TO MANIPULATE TRAP CROPS TO ACCOMMODATE PLANTING OPPORTUNITIES IN A DRYLAND SITUATION, OR DELAYED EMERGENCE FROM DIAPAUSE.

Conclusion:

Slashing chickpea crops at early flower can delay peak flowering for up to two weeks. However, the ability for a crop to fully recover from slashing and continue to flower is dependent on the availability of moisture. Potentially, available moisture limits the option of slashing to manipulate the timing of trap crop flowering.

Trap crop slashing trial 1999.

INTRODUCTION

In some seasons the opportunities for planting a spring trap crop are limited by rainfall events. This is particularly so in dryland areas where adequate planting rainfall may not occur within the window recommended by the Heliothis Regional Management Plan (HRMS) for planting a trap crop (late June-early July). Options for establishing and managing chickpea trap crops in dryland areas require some investigation. One option that is investigated in this trial is the possibility of delaying flowering of a chickpea crop through slashing. The ability to manipulate trap crop flowering has applicability in seasons where early planting opportunities occur, or where emergence from winter diapause is later than average and is not expected to coincide with trap crop flowering.

MATERIALS AND METHODS

A replicated trial was established in a dryland chickpea crop direct drilled into standing sorghum stubble in mid July, 1999. The trial was laid out in a replicated Latin Square with four treatments and four replications of each treatment. Each plot was 10m long by 5 rows wide. A buffer of 3 rows was left between each treatment and 1m of row separated plots on each end.

The four treatments were 1) control, 2) slash at budding (22 Sep and 11 Oct), 3) slash at flowering (28 Sep) and 4) slash at podding (21 Oct). Slashing was done with a handheld whipper snipper, reducing plant height by 50%. Measurements of plant height, flower number, pod number and heliothis density were taken at regular intervals between 22 September and 5 November. Trial data was analysed using an ANOVA for Latin Square (Genstat 5, v 4.2).

RESULTS

Flowering was delayed by approximately two weeks by slashing at early flower. Whilst flowering was delayed, the number of flowers produced per metre was significantly reduced compared with the density of flowers in the control treatment at peak flowering (Fig 4). This reduced recovery of the slashed plots is attributed to the limited soil moisture, which impacted on the ability of the crop to regrow vigorously.

Slashing at budding failed to delay flowering, but reduced the number of flowers. Slashing at early podding followed the peak in flowering, and the crop continued to produce flowers at a level similar to the untreated control, indicating there is no short-term advantage to slashing this late in the crop development (Fig 4).

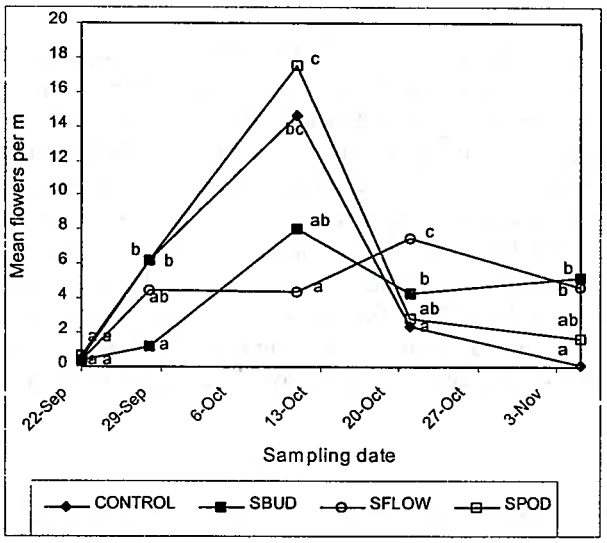

Figure 4. Influence of slashing on the timing of flowering, and number of flowers produced on a chickpea trap crop. Control = untreated, SBUD= slash at budding, SFLOW= slash at early flower, SPOD= slash at early podding.

RECOMMENDATIONS

Slashing at early flower is potentially a viable way to delay flowering in chickpea crops to ensure they are most attractive during the period of *H. armigera* emergence from diapause. However, the success of this technique is impacted by water availability for regrowth by the crop. Slashing at budding and podding were less effective in delaying flowering than slashing at early flower.

This technique has application in manipulating the flowering of areas of commercial chickpea crops planted in May-June (Darling Downs), when there may not be a suitable planting opportunity for a specific chickpea trap crop.

4.2 Determining the relative contribution of grain crops to the regional heliothis population

Conclusions:

The contribution of grain crops, with the exception of chickpea, is generally limited by the impact of parasitism, disease, and presumably predation. This results in a substantial decrease in the size of the heliothis population, from larvae to viable pupae. Most grain crops represent valuable nurseries for natural enemies, particularly the parasitoid wasps.

INTRODUCTION

At the outset of the HRMS project grain crops, particularly maize and sorghum were considered major contributors to the *H. armigera* population in the study areas. For example, the draft HRMS included a recommendation, for the December – February period, to "Avoid planting nursery crops eg. maize".

From the perspective of managing a local population of heliothis, it is important to understand which crops may be acting as nurseries for heliothis. With this knowledge, a management program can be developed, that emphasises monitoring and control in such nursery crops during the season. This is consistent with a regional management approach for a highly mobile pest like heliothis, which is 'to contain the pest where it is produced'.

MATERIALS AND METHODS

Intensive crop monitoring was conducted in 1998-99 and 1999-00 seasons to determine the level of survival and causes of mortality in grain crops. Throughout the cropping season from September through to April, grain crops were monitored for populations of heliothis. In each crop an estimate of larval density was made, and a collection of larvae placed on diet (25-50 larvae per site) and returned to the laboratory for rearing. Larvae were reared through to emergence as moths, mortality attributable to disease, parasitism or unknown causes were recorded. Predominantly second to fourth instar larvae were collected to maximise the chance of detecting parasitism by *Microplitis*, and mortality from diseases such as NPV and ascovirus. At an appropriate period after the larval collection the field was revisited and an estimate of pupal density made. Pupae were collected for rearing in the laboratory. In the second and third years of the project, egg collections were also made to allow an estimate of egg parasitism. This meant that heliothis populations in a field were investigated at three stages; egg, larval and pupal. The final pupal sample and collection provide the estimate of the contribution of the crop to the local population.

In conjunction with Wayne Rochester (UQ24C) cotton scouting data was collected from a number of farms in the study areas. Analysis of this data provided an indication of which crops were contributing to the overall egg pressure during the season.

RESULTS AND DISCUSSION

Production of heliothis in grain crops

The results of the crop monitoring were similar for the two study areas, therefore the results are presented by crop without separating the study areas. To demonstrate the relative survival of heliothis in each crop, larval and pupal data is combined and specific causes of parasitism (ie. *Microplitis*, *Heteropelma*) are not identified individually (Fig 5).

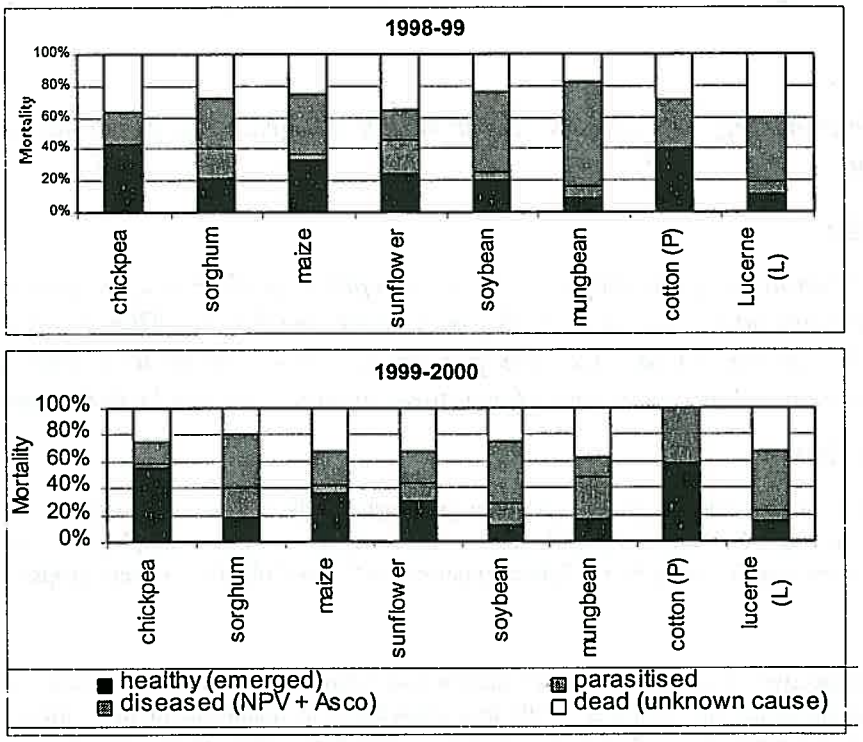

Figure 5. Overall mortality and survival of heliothis populations (larvae and pupae) in a range of grain crops and cotton in the 1998-99 and 1999-00 seasons. Data from the Jimbour and Brookstead study areas is combined. (P)= pupae only in data set, (L)= larvae only in data set.

Survival to moth is relatively low in grain crops (around 20%) with the exception of chickpea and maize. Chickpea experiences very little parasitism, and good in-crop control is critical to managing heliothis populations in these crops, as larval and pupal densities are relatively high (Fig 6). Maize has the potential to contribute a relatively large number of moths to the system, particularly late in the season. However, natural outbreaks of NPV are seen regularly in maize (which is not sprayed for heliothis), and specific application of NPV to maize crops in periods of high heliothis pressure would be a valuable regional management tool. The 'unknown death' component has still to be resolved as either field infection of some, as yet unidentified pathogen, or as an artefact of the laboratory rearing process.

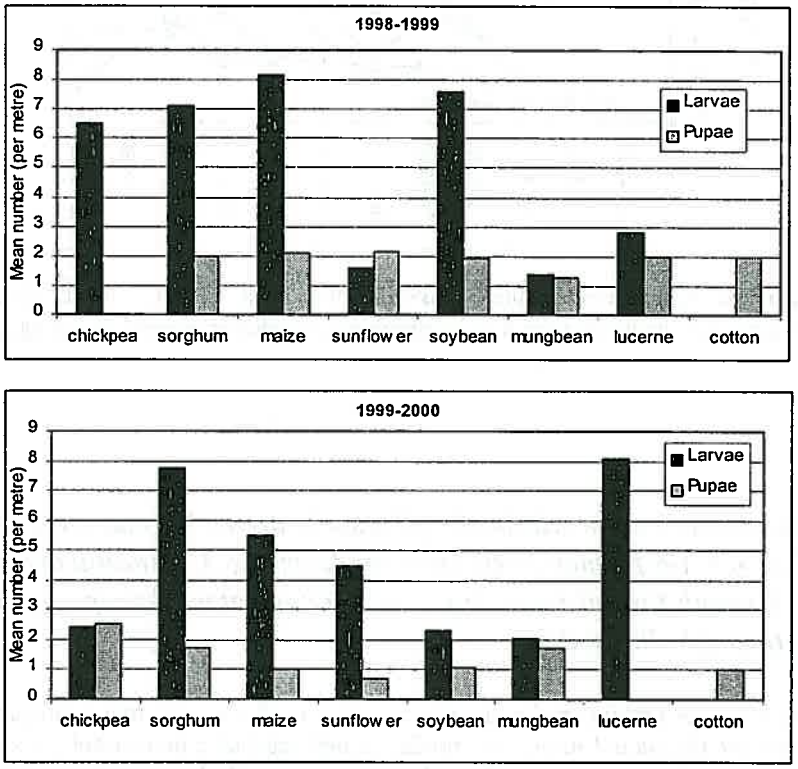

Figure 6. Relative densities of larvae and pupae in different crops within the pilot study areas during the 1998-99 and 1999-00 seasons.

The reasonable level of mortality seen in grain crops supports the results of the analysis described below which indicates that cotton is the major source of moths from January.

Seasonal pressure and sources of moths

Analysis of egg pressure across the Brookstead study area, in conjunction with backtracking development using the heliothis development model, allowed us to identify which crops were having a major influence on regional egg pressure during the season (Fig 7). Cotton is the only crop monitored regularly all season and provides an indication of season-long pressure in a region. The result indicates that commercial chickpea is potentially a major source of heliothis early in the season, and has previously been identified as requiring increased monitoring and improved control. This issue has been addressed in the GRDC-funded project (DAQ364, David Murray QDPI) which has some overlap with DAQ85C, particularly in terms of improving heliothis management in grain crops. The result also supports the anecdotal information provided by cotton consultants that heliothis pressure in cotton decreases during the period of peak sorghum flowering in December. The January peak in oviposition appears to have been generated by moths emerging from cotton locally (Rochester & Zalucki 2001).

With improved management of heliothis populations in chickpea and relatively low heliothis survival in other grain crops, research needs to address ways of decreasing the emergence and dispersal of moths from cotton from January in order to contain the population growth regionally.

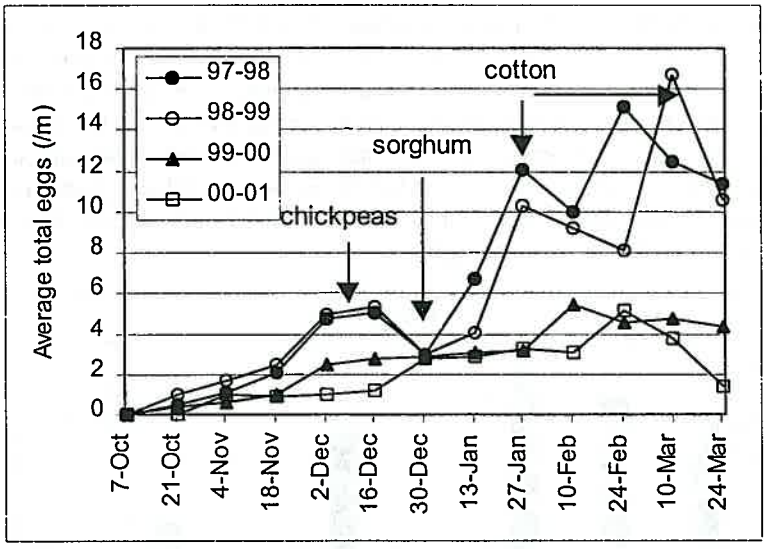

Figure 7. Average regional egg pressure for the Brookstead study area 1998-01. Backtracking development of ovipositing moths identified crops in the region as contributing to peaks or troughs in the egg pressure in cotton during the season.

4.3 Maintain communication within the pilot study areas, in relation to project progress, as well as general farmer discussion and learning. Communicate with industry and stakeholders through formal reporting, presentations at workshops, seminars and conferences, and through the media.

Regular communication has been maintained with growers and consultants operating in the pilot study areas. The monthly newsletter, the *Heliothis Hotline*, was produced and distributed to over 400 growers, agribusiness, consultants and extension staff on the Downs and in other regions. The *Hotline* contains updates on research, outcomes of discussions at HRMS groups and timely reminders for component activities. The demand for access to this information from outside the pilot study areas has grown considerably over the life of the project. It has been possible to expand the number of people receiving the newsletter, without increasing the cost of distribution, by using electronic distribution. Newly formed groups on the Darling Downs receive one copy of the newsletter, which a group leader then distributes amongst the group members.

Group meetings have been less frequent in the pilot study areas in the last 18 months of the project, with the onus on group members to decide if and when they wanted meetings, and determining the issues they want to discuss. Of the nine groups initially formed in the pilot study areas, four are meeting regularly at approximately 3-4 month intervals. Other growers continue to participate in implementing the strategy on their farms and in their local areas, but the group function has not developed as well as in these other groups.

Research and extension staff attended all meetings, providing feedback on research results and promoting discussion of issues related to pest management. All groups set goals for the season, primarily delaying the use of synthetic pyrethroids. At strategic times during the season, some groups met to discuss what options there were for managing heliothis, to get information from the project team on the level of natural enemy activity in local areas, and to talk with neighbours and consultants about how their pest management strategies were operating.

Communication with the broader farming community has been effected by involvement in a range of extension activities throughout the project. These have included:

- GRDC adviser and grower updates,

- an IPM Update held in Dalby to promote the HRMS and IPM-related research being undertaken by QDPI articles in the *Heliothis Stateline* newsletter, which is distributed to growers across Qld twice a year
- presentations at the Cotton Consultant's Association seminar series
- regular press releases provided to radio, television and print media in relation to the timing of spring trap crop planting, destruction and management; crop monitoring; general pest activity levels; pupae busting etc.
- Participation in the annual DAQ364 project review – an opportunity to communicate results and activities to researchers
- Participation in the Heliothis Working Group tour of QDPI's pest management activities
- Numerous presentations at, and participation in, farmer group meetings across Qld and NSW

Many of these activities overlap with, and are closely aligned with, extension activities of DAQ364 the "Heliothis management for IPM in grain crops" project.

Technical material, conference papers and other publications are listed in a following section.

4.4 The impact of HRMS on the local heliothis population, and the grower community.

Impact of HRMS on the local heliothis population.

This aspect of the project has proven to be more difficult than anticipated, and an exhaustive evaluation has not been possible to the level initially planned. One of the key difficulties has been the lack of a 'control' area with which to compare the pilot study areas. Although the project team has worked directly only with growers in the pilot study areas, key components of the HRMS (particularly spring trap cropping) have been implemented in all cotton-growing regions.

In terms of the direct impact of spring trap cropping on the local population of heliothis, the analysis by Wayne Rochester (Rochester & Zalucki 2001) was inconclusive and unable to demonstrate any direct association between the presence of trap crops and subsequent heliothis pressure in nearby cotton. However, as discussed in their report, the data available for analysis was not sufficient for a thorough analysis.

The three years of the project (98-99, 99-00 and 00-01) have been characterised by lower heliothis pressure in both the study areas, compared with the preceding season (1997-98). It is difficult to partition the impact of the regional management activities from the impact of the adverse seasonal conditions on the size of the local heliothis population in these three seasons. The evaluation of the direct impact of regional management on the heliothis population requires significant development of techniques. This is one area of the project that has not been accomplished to the extent intitially anticipated.

Impact of HRMS activities on the grower community – development and initiation of evaluation.

The impact of HRMS on the participating growers, consultants and the local community has been monitored throughout the project. Changes in attitude, knowledge and practice have been documented through a grower/consultant survey, and by records from group meetings. This evaluation, which describes changes in the pilot study areas, is presented below in the form of Bennett's Hierarchy, showing the transition of individuals and groups through participation in the HRMS.

Increased grower knowledge and understanding of heliothis management and integrated pest management (IPM).

There has been a dramatic change in the knowledge and understanding of growers of heliothis management and IPM over the duration of this project. At the beginning of the project many growers didn't fully understand the heliothis life cycle, making it difficult to then understand why certain tactics of the strategy were in place. For example, a Jimbour Flood Plains grower claimed in April 1998 that he didn't know that heliothis spent part of its lifecycle under the ground. Given this level of understanding, the practice of pupae busting would have seemed irrelevant, and its importance in an IPM strategy would not have been realised. This knowledge changed quite quickly as evidenced by the high participation rate in the pupae-busting program.

Another area that saw a rapid change in knowledge was in relation to beneficial insects. In April 1998 comments were made a meeting that, "beneficials aren't important" and " we don't have any beneficials on the Downs". This knowledge changed after a number of meetings and demonstrations. By October 1998 growers were making comments at meetings such as, "pyrethroids were used in winter cereals (a good host for beneficials), will the beneficials come back?" and "Barley and sorghum will contribute to beneficials".

In more general terms, the knowledge of growers has advanced from a basic understanding of how to use chemicals to control the major pest species in the farming system. The majority of growers now have an understanding of the heliothis life cycle, an understanding that there a number of non-chemical options for controlling this pest, and an understanding of why they have the potential to work. At the mid-project review with participants in October 1999, growers thought that "awareness has increased, but things haven't changed a lot". This reflected a change in attitude of growers and reflected a desire to do more with their newly acquired knowledge.

Change in attitude to heliothis management from pesticide dependence towards IPM.

Growers have realised that they can take control and have a real impact on pest management in their farming systems. A recent comment from an on farm agronomist in the Brookstead pilot study area summed up the change in attitude when he said, "We originally thought that the new ideas were all pie in the sky, but now we realise that we can have an impact. It isn't all just good luck. We are creating our own luck."

The most significant change in attitude of the participants is in relation to beneficial insects and use of soft chemistry. Consultants and growers have changed from viewing beneficial insects as unimportant, and even non-existent in some cases, to wanting information about beneficials, what impact they can have, and what they can do to encourage them. Attitudes to the use of soft chemistry, and particularly the biological products (virus, Bt, heliothis specific products) has become more positive following experiences of good control with these products under the relatively low pest pressure in the 99-00 and 00-01 seasons.

Early in the life of the project, groups did not spontaneously discuss the use of selective chemistry. By the third round of meetings growers were starting to make comments such as; "the soft options are limited by pressure", "go soft early, then when pressure gets to high go hard", "need to be prepared to weather more damage". As well there was some discussion about the chemical recommendations of consultants and advisers being contrary to the desire of growers to 'go soft'. By February of 1999 Brookstead growers were starting to make comments such as; "selective chemistry is an important component", "get rid of 'hard' chemicals, early season" and "we need a balance between soft chemistry and fruit retention." In October 1999 the Jimbour growers wanted to see greater use of NPV, and realising the relevance of soft options in grain crops. By December 2000, growers at Brookstead were acknowledging the advantages from 'going soft' in terms of reduced subsequent pest pressure, as a result of preserving beneficial insects in the system. Clearly the growers were gaining an understanding of the benefits of soft chemistry, and their role in the farming systems (grain and cotton).

The role the DAQ85C and DAQ364 project teams have played in achieving this change in attitude cannot be underestimated. The successful introduction of virus (Gemstar®) for sorghum and other grain crops has been pivotal in developing grower confidence with 'soft options', and biological products in particular. Research and extension support assisted growers with developing confidence in using non-traditional products through discussion of research data, providing data and feedback on pest and beneficial activity in the pilot study areas throughout the season, and participation in grower discussions of their experiences in the field.

Widespread implementation of the HRMS, and adoption of key components into pest management activities (practice change).

Participants in the HRMS were quick to adopt some of the tactics and slower in adopting others. Trap cropping was one of the new technologies in the strategy, and it was one that growers quickly increased their knowledge about. This was achieved by asking many questions at the early meeting, and determining for themselves, on the basis of what they understood trap cropping to be, that it was a technique well worth trying. The rate of adoption of trap cropping was very high from the beginning of the project at Jimbour in 1998, 27 growers (33%) participated and at Brookstead 48 growers (43%) participated.

Pupae busting was another key component of the strategy that saw a high rate of adoption from the beginning of the project. In February 1999 growers in the Brookstead area believed that all irrigated growers were pupae busting, but there was some dryland growers that were not, most likely for soil moisture and erosion risk reasons. In the mid-project review October 1999 growers in the Brookstead area thought that the pupae busting and trap cropping would continue past the life of the project, illustrating that the participant were already implementing and satisfied with the perceived contribution of these key components to heliothis management.

Another key component of the strategy was to delay disruptive pesticides and promote beneficial insects. This was a part of the strategy that was adopted more slowly by participants. At the beginning of the project growers did not consider that beneficials insects made a significant contribution to heliothis control, so they could see little reason to preserve them. It has been rewarding to see this attitude change during the course of the project to the stage now where growers are monitoring and using beneficials in pest management. They are incorporating them into pest management decisions and actively trying to augment them in the farming systems. Some grower comments that illustrate the state of beneficial-related discussion at grower meetings include.

- "Beneficials are coming in from grazing country",
- "Thrips are acting as beneficials against mites",
- "Numbers of beneficials dropped off late in the season, especially due to the sprays in cotton",
- "If we loose our beneficials mid-season it is hard to recover, we need to look at importing beneficials from other areas"
- "Planting into stubble helps build up numbers",
- "Is it worth putting $1-2/ac of cotton across the area to fund an area-wide release of *Trichogramma*?"
- "There are predatory shield bug in the crops and some parasitic wasps" and
- "I look forward to time when Bt/virus/parasites cam take out the population of escapes ie. true working IPM."

There were a number of growers in the Jimbour region that did some inundative releases of the egg parasitic wasp *Trichogramma* during the summer of 2000/2001, illustrating how far they have progressed along the IPM path.

Development of grower groups in pilot study areas (Increased communication) – flow on benefits of the project

At the beginning of the HRMS project it was decided that to be effective we would need to operate with a number of groups within each study area. The Brookstead region was split into five groups and the Jimbour Flood Plain was split into four groups. The Jimbour groups were each comprised of two established Landcare groups. Early in the project (March/April 1998), the groups were asking many technical questions and looking for the DPI to provide solutions for them. This continued into July 98, when growers largely understood and had adopted the spring trap cropping and pupae busting program.

By October 1998, awareness of specific component issues, and possible solutions, had increased. Jimbour growers were starting to look for ways of improving their perceived lack of beneficials on farm eg. lucerne plantings. The Brookstead growers were talking about going "soft" (using the least disruptive available chemicals), although this was not what happened in practice during the 1998/99 season.

By February 1999, growers were requesting more information about beneficial insects and how to optimise them in the farming system. Growers were requesting training sessions on IPM techniques. The Brookstead growers were still a little sceptical about how successful IPM could be in the paddock, given their recent experience with another season of high pest pressure.

By May 1999, the Jimbour growers showing a high level of commitment to the project, but a little more cautious about going soft for too long (ie. moving beyond their comfort/confidence zone). Both regions were requesting information on lucerne, indicating that they thinking about changing the farming system to be more beneficial- friendly. The Brookstead growers were still looking for answers/recipes from the entomologist,

consultants or the extension officer. They continued to make excuses for why they could not employ IPM tactics. Following the mid-project review of progress and aspirations with the groups in October 199, an overall assessment of group development at this stage was that the Jimbour growers were clearly looking to the future in a much more group orientated manner than the Brookstead group. The Brookstead group continued to focus on outside help and direction from DPI, whilst the Jimbour growers had placed more importance on the value of the groups and being self-driven.

The Jimbour growers initiated a 'crisis' meeting at the end of December 1999. They made a decision, as a group, to delay the use pyrethroids as long as possible and make us of the beneficial resource they were seeing in their field. It was not until June 2000 that the Brookstead growers started to use the group meetings to discuss different options and strategies (such as summer trap cropping), progressing as a group. The Jimbour growers were continuing to use the meetings as a basis for discussion, but had the advantage over the Brookstead groups that they now had some real experiences with the impact they could have on farm through the preservation of beneficial insects.

The Jimbour groups had moved to the level of implementing new practices and techniques, whilst the Brookstead groups were still largely just talking about concepts. However, there was a change in topics for discussion; more focus on beneficial insects, less on managing pesticides and spray application. Growers were also perceived to be starting to feel more in control of their own problems.

An "IPM Progress on the Darling Downs Update" was held in August 2000. Around 120 growers and advisers attended this update, reflecting the changing attitudes and interests of growers and consultants across the region.

By December 2000, Brookstead groups were starting to ask the searching questions that the Jimbour group do in relation to beneficials and how to encourage them. Some growers were planting beneficial nursery crops and thinking about egg parasitoid releases.

At the end of the project it is clear that the Brookstead groups are now operating more successfully as groups, but they are still not quite as effective as the Jimbour groups, which have a longer history of working together as Landcare groups.

5. LIKELY IMPACT OF THE HRMS ON THE COTTON INDUSTRY

Increased profitability of growers as a result of reduced heliothis pressure.

It is difficult to estimate the scale of the decrease in heliothis pressure that might occur with the success of regional management of heliothis. However, we can speculate that the pressure decrease may be at least of the same magnitude as the decrease in local pressure seen between the 97-98/98-99 and 99-00/00-01 seasons (Figure 8). Egg pressure in cotton is used as an indication of regional egg pressure. Cotton is the only crop in the system that is present throughout the summer period, and in which pest density is regularly recorded.

Comparative economic analysis of heliothis control in cotton for the 98-99 and 99-00 seasons has been undertaken by Fisher & Wicks Consulting. No regional analysis has been done for the Brookstead or Jimbour areas, but one has been done for the Goondiwindi region, which experienced a similar reduction in heliothis pressure in the two seasons. The analysis showed average insect control costs for conventional cotton were $799/ha in 98-99 and $365/ha in 99-00, a reduction of $434/ha or 54% (Chris Wicks, personal communication).

In an environment of lower heliothis pressure, it is viable to use a biological product such as Dipel®(Bt) or Gemstar®(NPV). The selectivity of these products preserves natural enemies, which have been found to make a significant contribution to egg, larval and pupal mortality in undisrupted grain and cotton crops (eg. *Trichogramma* sp., *Microplitis*/ascovirus, *Heteropelma*, Tachinidae). Efficacy of these products in cotton and grain crops, particularly early in the season, has benefits to the farming system as a whole. These flow on benefits are difficult to quantify, but have a significant value:

i) increased control of heliothis populations by the use of biological products to which there is no resistance in the population (virus), ii) resistance to the carbamates is not exacerbated by repeated use, particularly as a result of early season use in chickpea, iii) preservation of natural enemies makes a contribution to heliothis control not

only in the treated field, but following dispersion to neighbouring and subsequent crops. These aspects are of particular importance in the context of heliothis management on a regional scale, and the scale of impact and benefits will extend across the grain-growing areas of Qld and NSW as the adoption of HRMS and IPM becomes more widespread.

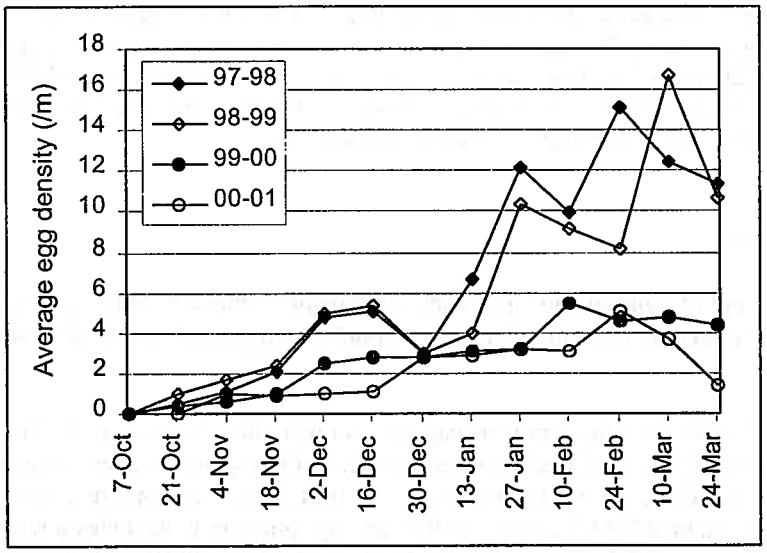

Figure 8. Average fortnightly heliothis egg density recorded in cotton from across the Brookstead-Cecil Plains pilot study area 1997-98, 1998-99, 1999-2000 and 2000-01 seasons.

a. Major conclusions

1) **A farming systems, or regional, approach to the management of Helicoverpa armigera is feasible both in scientific and practical terms.**

Based on our current understanding of H. armigera ecology the HRMS was devised to reduce the size of the local population, and would only be effective if the population was not subject to significant immigration events during the summer season. Temporal analysis of season-long heliothis pressure in the pilot study areas (Wayne Rochester, UQ) has demonstrated that there is no substantial migration into the region during the summer period. This assertion is supported by preliminary results from the DNA microsatellite studies (Glenn Graham, CID, UQ) that suggest the H. armigera population on the Darling Downs is genetically distinct from populations in other cropping regions. Therefore, the fundamental prerequisite for an effective HRMS, a local population, exists on the Darling Downs.

Key component tactics of the HRMS, spring trap cropping, pupae busting, improved heliothis management in grain crops, have been trialed by growers on their own farms. Growers have demonstrated these tactics to be practical to implement, with some modification, on all farms from conventional tillage through to zero tillage.

2) The rapid adoption of new pest management concepts and tactics is greatly facilitated by a participatory and group approach to learning.

Growers in the HRMS pilot study areas readily implemented and evaluated the practicality of recommended tactics on their own farms over the life of the project. This outcome is attributable to the intimate involvement of growers with the project team, and particularly to the ongoing support and encouragement provided by the extension officer in the project. Growers have responded well to having continuity in terms of contact personnel, and have made extensive use of the availability of the extension officer to provide support and/or information during the cropping season.

Having a specialist extension officer with technical experience in pest management, as well as facilitation skills, has been key to the confidence with which growers have attempted new activities. In addition, the sound technical knowledge of the extension officer has made it possible to communicate research results from the research team to growers. The skills of the extension officer have made it possible to present the information with adaptation and interpretation that makes it immediately accessible to the growers.

Working in groups has resulted in a high level of communication amongst growers, as well as between growers and the project group. The opportunity for communication amongst growers has been important in fostering the appreciation that heliothis management needs to be considered on a scale larger than that of the individual field or farm. This has been critical to creating the 'regional' mindset central to the implementation of a Regional Management Strategy for heliothis.

b. Recommendations

1) **Regional management of heliothis, or area-wide management, has developed as a movement in farming communities across Qld and NSW, and should be supported with both research and extension.**

Not only does HRMS offer benefits for the management of heliothis, the major pest of most field crops in the northern region, but it has developed into a movement that has spawned an enthusiasm for alternative pest management approaches, and particularly interest in IPM. Now is an opportune time to capitalise on the interest and enthusiasm in IPM that exists in the farming community. Attitudes towards pest management are changing, and there is an overwhelming demand for information and options that the current research and extension resources cannot service.

The current HRMS represents a first step in the introduction of the regional/area-wide management concept to the farming community. Additional research is required to supplement the basic component tactics of the current Strategy to extend the capacity of growers to impact on local heliothis populations. Areas requiring research include summer trap crops, augmentation of natural mortality through the preservation and/or breeding, and manipulation of natural enemy populations within the farming system.

Experienced and specialised staff are needed in all growing areas to assist growers as they implement tactics and strategies that are unfamiliar, and perceived to be high risk. For growers to aquire new skills and gain the confidence to implement new tactics, they require ongoing support and information. In the absence of such support, growers will persist with the 'tried and true' methods of pest management, which are highly dependent on chemical control.

c. Other R&D opportunities that emerged during the course of the project

1) **The role of natural enemies of key pests** has emerged as an area of research requiring attention. With an increased awareness of natural enemies, and a greater understanding of the biology and ecology underlying pest behaviour, growers are keen to explore ways to exploit natural enemies to increase pest mortality in their fields. A number of growers have moved beyond assuming that 'soft' insecticides will mean more natural enemies, to a point where they are actively attempting to augment natural enemy populations on their farms by inundative release (eg. *Trichogramma*) and propagation in nursery crops (eg. lablab, lucerne, niger).

In a mixed cropping system, such as exists on the Darling Downs, the opportunities for area-wide management of natural enemies has huge potential. There are many questions that need answers before such a strategy becomes possible. For example, (a) which are the key natural enemy species that have greatest impact on pests, (b) do the natural enemies have specific crop or pest associations and (c) can populations of natural enemies be manipulated to be active in crops when pests are active ie. numerical and temporal manipulation.

2) **The expansion of the regional management concept to other regions**, particularly agricultural systems that are less diverse than those of the Darling Downs. From a regional management perspective, the benefit

that a diverse system offers is considerable. Research as part of DAQ85C, has clarified that at different times of the season, particular crops act as heliothis 'sinks' and/or natural enemy nurseries. In other regions where larger fields predominate, and the diversity of crops is less, HRMS may be more dependant on spring trap crops, or in-season trap crops to manage the heliothis population. How the HRMS could be modified to be effective in other cropping systems is an area for further research and development.

6. COMMERCIALLY SIGNIFICANT DEVELOPMENTS, PATENTS OR LICENSES

No commercially significant technologies were developed through this project.

7. PLAN FOR ACTIVITIES:

(a) to further develop or to exploit the project technology.

With the commencement of DAQ112C "Heliothis management in southern Queensland farming systems" there is an opportunity to capitalise on the progress made to date with DAQ85C. Results of research, development and evaluation suggest key areas that require further investigation to develop additional tools/tactics to supplement the draft HRMS. These areas are discussed in the section on R&D opportunities, but briefly, may include:

- containing the heliothis population in cotton through improved control, increased mortality in crop or manipulating emerging moths to prevent dispersal into the farming system
- greater exploitation of natural enemies within the farming system through the use of existing 'nursery' crops that exist in the mixed farming systems that occur in much of southern Qld
- investigating the opportunities to transfer the HRMS to other regions, including identifying necessary modifications that may be necessary to make the strategy effective in less diverse farming systems.

(b) for the future presentation and dissemination of the project outcomes.

The demand for the DAQ85C project team to present results and outcomes of the HRMS to groups across the cropping regions of Qld and NSW continues. The project team continues to be involved in grower meetings, presentations to consultants and growers and to stakeholders. Under the auspices of DAQ112C, the *Heliothis Hotline* will continue with sponsorship from local companies to cover the costs of distribution. One of the initial outputs of DAQ112C is to develop a communications plan. The plan is essential to determine how the output and outcomes of DAQ85C can be communicated widely and effectively to the broader farming community. It is essential that future communication and dissemination of results does not stall and be purely repetitious of what has been done to date. It is equally important that current knowledge be developed and extended as research builds on the current HRMS. Future presentation and dissemination of the outcomes of DAQ85C will be achieved in this context.

8. PUBLICATIONS ARISING FROM THE PROJECT

Technical brochures

Boddington J, and Murray D. 1998. *Chemical-free heliothis pupae control.* CropLink Brochure

Boddington J, and Murray D. 1998. *Spring trap crops snare damaging heliothis.* CropLink Brochure

Boddington J and Murray D.1999. *Know the enemy: heliothis ecology and biology for better control*

Ferguson J, Miles M, Murray D, Dillon M, Kauter G, Lloyd R and Sequeira R. 2000. Spring trap crop management guidelines.

Conference Proceedings

Murray, D, Boddington J, Lloyd R, Rogers J, Zalucki M and Ward A. 1998. *Regional Management of heliothis on the Darling Downs.* Proceedings of the Ninth Australian Cotton Conference, Broadbeach. Pp 351-355.

Murray M, Miles M and Ferguson J. 2000. *Area-wide management of heliothis – results of current studies.* Proceedings 10th Australian Cotton Conference, Brisbane.

Miles M, Boddington J, Murray D and Bull T. 1999. *Area-wide management – challenges and opportunities.* Proceedings of the CCA Cotton Production Seminar. Goondiwindi 26-27 Aug.

Zalucki MP, Miles M, Murray DAH and Rochester W. 2000. *Landscape scale cultural control: future prospects and limitations.* Proceedings of the XXI International Congress of Entomology, Iguassu Falls, Brazil.

Miles M and Ferguson J. 2001. *Heliothis Regional Management on the Darling Downs: An overview and evaluation of the project.* Proceedings of the CCA Cotton Production Seminar. Goodiwindi 21-22 Aug.

Popular press articles

Miles M, Ferguson J, Murray D and Bull T. 2000. *Area-wide management on the Downs: Do we have a strategy?* The Australian Cottongrower. Pp30-37 Sep-Oct

Other

Heliothis: Regional Management. 2000. Video 23 mins.

The production of the *Heliothis Regional Management* video was an intitiative of the *Darling Downs Heliothis Working Group* (HWG), with considerable input from the DAQ442 team. The aim of the video was to inform growers and agribusiness across southern Queensland of the changes in *Helicoverpa* management being trialed as part of the HRMS, the potential benefits and successes. The views of a wide range of growers, consultants and researchers were canvassed for inclusion in the video. The video was officially launched by the Qld Minister for Primary Industries, the Hon. Mr Henry Palaszcuzuk, in September 2000. Copies of the video were distributed to approximately 2500 grain and cotton growers, agribusinesses and consultants across the Darling Downs. Additional copies were made available to extension staff across Qld and NSW. Cost of production and distribution was covered by sponsorship from a range of grower and agribusiness groups.

9. Are changes to the Intellectual Property register required?

N/A

References

Rochester WA and MP Zalucki. 2001. *Heliothis migration and pest management: Effects of movements within and between cropping regions.* Final Report to CRDC for UQ24C. 25 January 2001.

Part 4 – Final Report Plain English Summary

Provide a half to one page Plain English Summary of your research that is not commercial in confidence, and that can be published on the World Wide Web.

A draft regional management strategy for heliothis was devised by researchers (QDPI, University of Qld) and leading growers, as a starting point for the research, development and implementation of such a strategy. The strategy was produced as a year-long activity plan for growers, identifying specific activities and actions that should be implemented to comply with the strategy.

The draft strategy provided a starting point for growers and their advisers to visualise how the components of the HRMS fitted together in the scheme of an annual farm program, rather than on the basis of seasonal field-by-field management. The draft strategy was first presented and explained to growers at a meeting in each of the designated study areas. With a strong level of support and commitment for the trial of the HRMS, from growers, the implementation, research, development and evaluation phase of the project commenced. In the Brookstead-Cecil Plains study area 119 growers were involved in the project, and 83 growers were involved in the Jimbour Floodplain study area. In addition, there was involvement from agronomists, consultants and other agribusiness interests associated with these growers.

Whilst growers implemented the component tactics of the HRMS, research was undertaken to evaluate and refine these components, and to evaluate the appropriateness of the HRMS in the Darling Downs farming system. Recommendations relating to the use of spring trap crops, management of heliothis in grain crops and pupae busing have been confirmed, and/or refined, as a result of the research conducted. For example, trials over three seasons have confirmed chickpea to be the most suitable crop for spring trap cropping on the Darling Downs. Agronomically the crop is robust; the timing of flowering can be manipulated by slashing; relative to other candidate crops (vetch, niger, canola, canary, linseed, field pea, lentil) it is highly attractive to heliothis. The recommended planting date of late July – early August, have proven to be robust over three seasons, the extended flowering coinciding with the emergence of the *H. armigera* population from diapause in all seasons.

Progress by growers towards the successful implementation of the HRMS, has been facilitated by disseminating such project results, revised recommendations and grower experiences. Primary dissemination has been via the *Heliothis Hotline* and *Heliothis Stateline* newsletters, industry seminars and conferences, farmer meetings, and technical brochures.

Communication of project activities, progress and research outcomes to the broader farming community has promoted the widespread adoption of the HRMS concept. Implementation of key strategy components (eg. spring trap cropping) is occurring across Queensland and NSW. Beyond the end of DAQ85C, the project team continues to communicate with farmer groups and industry. Requests continue from groups outside the pilot study areas to get information and assistance with the implementation of HRMS activities in their areas. The awareness and uptake of the project output is high, and continues to extend beyond the Darling Downs. It is anticipated that all grain-cotton-growing regions will have functional area-wide groups within two years.