January, August & Final Reports

REPORTS

Part 1 - Summary Details

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

CRDC Project Number: **DAN141C**

January Report:	☐	Due 29-Jan-01
August Report:	☐	Due 03-Aug-01
Final Report:	☒	Due within 3 months of project completion

Project Title: Role of Conventional and Novel Insecticides in Integrated Pest Management (IPM) in Cotton

Project Commencement Date: 1/7/99 **Project Completion Date:** 30/6/02

Research Program: Insect Management

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Part 3 – Final Report Format

1. Project Background

Helicoverpa spp. are still the primary pests of cotton in Australia. Chemical control available for these pests consisted of a limited selection of conventional insecticides. These insecticides were from key chemical groups still used by the industry include carbamates, organophosphates and synthetic pyrethroids and because of their broad-spectrum activity they significantly disrupt most predators and parasites (Wilson et al., 1998), and in some cases have a negative environmental impact. Frequent chemical spraying resulted in the development of resistance to some of these chemicals by *Helicoverpa* spp., eg. carbamates and synthetic pyrethroids. To counter resistance issues, new insecticides are being developed and registered for control of *Helicoverpa* in cotton. This new generation of insecticides are promoted as being more selective, less disruptive to beneficial and therefore more compatible with IPM (Holloway, J., Forrester, N., 1998). Cotton growers now have the choice of selecting from “old” and “new” insecticides when deciding to apply insecticides. Knowing the efficacy of individual insecticides against the target pest species is insufficient to make these decisions. It is also important to have knowledge of how these insecticides impact on other pests, predators and parasitoids. Strategic use of conventional insecticides in an IPM strategy will not only assure their efficacy but also prolong their existence for cotton insect management programs. Therefore, “old” and “new” insecticides should be rotated and placed in a way that they will perform effectively and soundly within the integrated pest management (IPM) and the integrated resistance management (IRM) strategies.

This project was established to look at various aspects of insecticides in cotton and the factors that would directly affect decision making. These aspects include:

1. Continual use of conventional insecticides to control insect pest (esp*. Helicoverpa* spp.) in cotton.
2. Evaluation of the efficacy of new insecticides.
3. Looking at insecticidal efficacy when used on conventional versus Ingard cotton varieties.
4. Collect data, which can be used as an indication of the field resistance level of insect pest to specific insecticide or group.
5. Test and refine the use of the custom designed eight-line sprayrig for trial purposes.

In this project, new insecticides (both newly registered and yet to be registered) were tested for their efficacy in controlling *Helicoverpa* spp. This project also generate an independent dataset on efficacy and impact of specific chemical on other pests and non-target species (beneficial).

Ingard varieties (*Bt* cotton) have the potential to reduce insecticide use for control of *Helicoverpa* spp. by 50-70%(Fitt, 2000). Since the introduction of transgenic cotton where the expression of *Bacillus thuringiensis* subsp. *kurstaki* CryIAc delta endotoxin can control *Helicoverpa* spp., insect management strategies for cotton have changed. Bt cotton results in a significant reduction in the number of insecticide applications, especially during the first half of the season. This means that during the second half of the season when the expression of CryIAc in transgenic varieties starts to decrease there is a need for supplementary insecticides to target *Helicoverpa* spp. Due to the delayed use of insecticides, secondary pests are likely to become an earlier problem. Hence, the efficacy evaluation of new insecticides in conventional versus transgenic cotton was necessary.

The use of the unique eight-line sprayrig (funded by CRDC and built to specification) has enabled a precise and efficient evaluation of insecticides in the field situation.

Close contact with other researchers (Dr. Lewis Wilson, Dr. Robin Gunning, Dr. Robert Mensah and Dr. Grant Herron) involved in IPM or IRM has been kept.

2. Project objectives

(i) Evaluate the efficacy of new products for *Helicoverpa* control

Helicoverpa pressure during the 2000/01 and 2001/02 seasons was quite low, however, there were still sufficient eggs and larvae to show efficacy differences between various chemicals when compared to the untreated control.

In most cases the new products proved to be very effective in controlling *Helicoverpa* species at various stages of their life cycle and during the season. When comparing the efficacy of these new insecticides to the untreated control, Tracer and Steward were the most effective while Rimon and Prodigy was the least.

(ii) Evaluate the efficacy of new products on other pests, predators and parasitoids

Counting and identifying D-vac samples showed very interesting trends. Rimon and Prodigy were as good as the untreated control with the highest number of beneficial while Tracer and Intrepid were more desruptive having least beneficial. S1812 (a new product from Sumitomo) and Steward were very effective on other Hemiptera and Coleoptera pests while Agrimec and Affirm showed good control of aphids.

(iii) Comparison of the insecticidal effect of insecticides on conventional versus Ingard varieties

Results from the 2000-2001 season showed that Prodigy, Rimon and S1812 are not significantly different from the untreated control in their effect on *Helicoverpa* small larvae in the conventional variety. In contrast, these same chemicals were significantly better than the untreated control in controlling *Helicoverpa* small larvae in the Ingard variety. This difference is thought to be primarily due to the variety factor as the ANOVA showed that variety had an overriding impact.

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

Apart from independently identifying the efficacy of the new insecticides against target pest species, essential data on the impact of these compounds on other pest, predators and parasitoids has been collected. Generally this information is not fully provided by chemical companies, yet it is vital information in determining the position of new insecticides within the IPM guidelines and the IRM strategies.

Lower production costs due to fewer insecticide applications increase the profitability of growers. Fewer insecticide applications will also have a reduced impact on the environment. Emphasising the benefits of IPM within the Best Management Practices (BMP) of cotton production systems will encourage growers to look at farming system approach to pest management and thereby ensure that cotton production remains competitive.

4. Methodology used.

During the three years of this project research has been carried out on both synthetic and biological insecticides (Appendix I). The insecticides were tested on conventional and transgenic cotton varieties. Based on standard experimental designs such as Randomised Complete Block Design and Split Block Design. Replicated small plot trials were conducted at ACRI, Myall Vale, to compare the efficacy of a number of insecticides. New insecticides included Abamectin, Emamectin, Spinosad, Novaluron, Indoxacarb, Methoxyfenocide, Chlofenapyr, S1812 and biological insecticides such as Foliar *Bacillus thuringiensis* (Costar), Nuclear Polyhedrosis Virus (NPV) (Gemstar) and *Azadiractin* (Neemsal TS). Also included in the trials were some old insecticides such as Deltamethrin, Methomyl, Thiodicarb and Chlopyrifos. Each insecticide was based at label rates or on recommendation from the manufacturer. Insecticides were applied using a specially constructed spray rig with commercial application volumes of 100 or 150 L/ha, hollow cone nozzles (TX4 or TX6), at 3 bar pressure and 5km/hr speed. This sprayrig enabled the application of 8 chemicals per run reducing soil compaction, application time and costs.

The total number of *Heliothis* eggs and larvae were visually assessed on all plants in a randomly chosen metre in every plot (planting rate 15plants/m). The assessments were carried out at 2, 5, 7 and 10 days after treatment application or as close to these days as possible. D-vac machines and cloth bags were used to collect samples from 15 metres in every treatment plot both during the 2000/01 and the 2001/02 seasons. These samples were processed in the laboratory and all mites, insects and arachnids were counted and identified using a stereo microscope. Using two methods of assessment ensured that as many pests and beneficial as possible were captured. Visual assessment serves well for any Lepidopteran pests as well as for aphids and mites. D-vac suction samples manage to catch a large proportion of flying and crawling insects such as Hemiptera, Coleoptera, Neuroptera, Diptera and Arachnida. Field trial data were recorded and analysed using the statistics program Genstat for Windows, 5th Edition.

5. **Detail results including the statistical analysis of results.**

All results are presented in Appendix II

List of insects/groups referred to in discussion in Appendix III

6. **Discuss the results, and include an analysis of research outcomes compared with objectives.**

The average numbers of *Helicoverpa* spp., other insect pests and beneficials are presented in Figure 1, 2 and 3. This graphs serve to show the presence of each group of pest and beneficial in comparison to each treatment and the control used in the trials (in this case – 'New'Insecticides Trial). This information can be used to consider the effect a chemical has on target and non-target species. eg. Tracer is the most effective chemical controlling Helicoverpa spp. (Fig.1), however, it has a low impact on other pests(Fig.2) and a moderate effect on beneficials (Fig. 3).

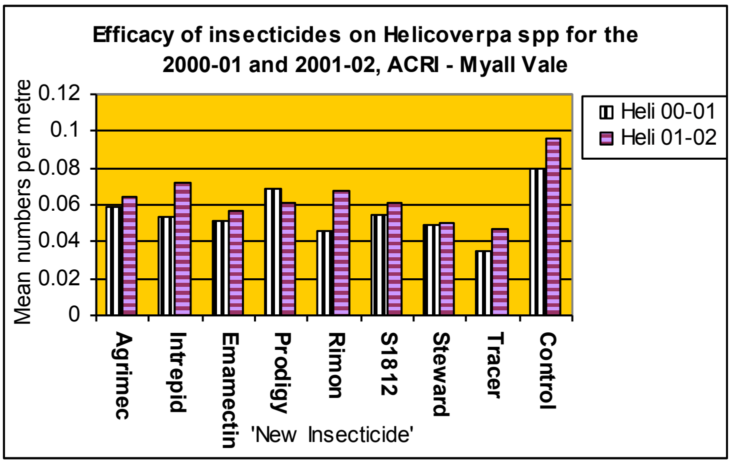


Figure 1

Figure 2

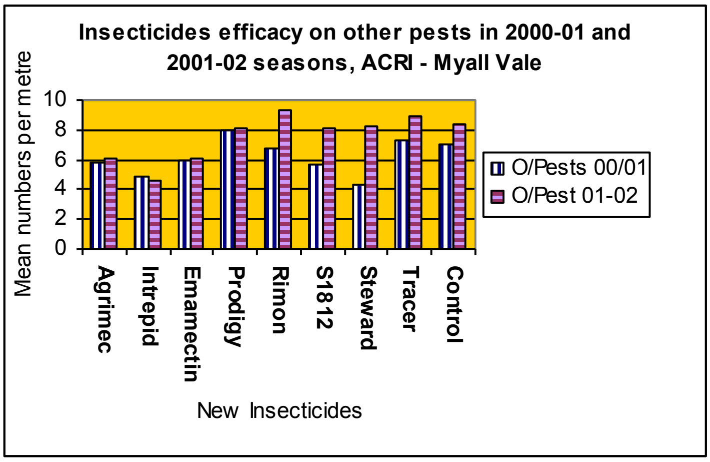
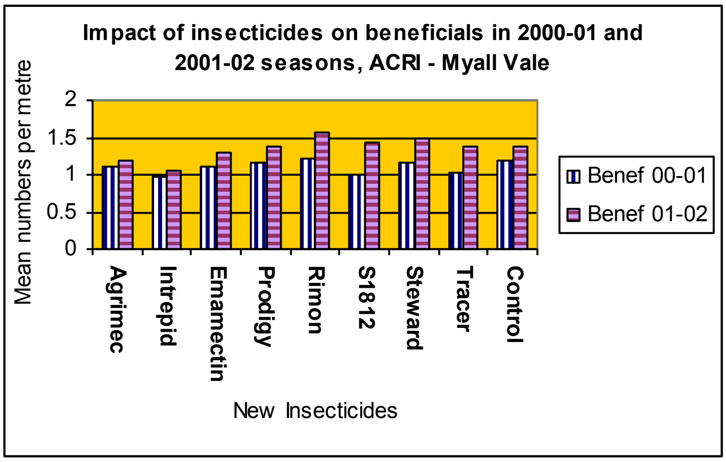


Figure 3



Details of this trial and other trials are discussed below.

1. NEW CHEMICAL GROUPS – EFFECT ON *HELICOVERPA* SPP. AND OTHER INSECTS

Effect of Variety

Variety had a significant effect on the mean number of all larvae except very small larvae (Table 7). This is most likely due to the very low numbers present or detected during the visual checks. Mean numbers of larvae in the Ingard plots were significantly lower than in the conventional cotton plots.

Effect of Treatments

Analysis over both varieties: There were no significant treatment effects on eggs (Table 8) as the chemicals used in this trial are primarily used as larvicides. For very small, small and medium larvae all treatments were significantly better than control, Tracer and Intrepid being the most effective. Tracer was significantly better than Rimon, Agrimec and Prodigy. For medium larvae, Tracer was significantly better than Prodigy was; all others were about equally effective. For large larvae, compared to the control, significantdifferences were found in all treatments except Agrimec and Prodigy.

Analysis of Conventional variety only: 2000/2001 - There were no significant treatment effects on eggs. Tracer and Intrepid were most effective on very small, small and medium larvae while S1812 and Tracer significantly reduced large larvae. It is unlikely that any of the chemicals that affected medium and large larvae would not also affect very small and small larvae. Due to low insect numbers the lack of significance of these treatments is most likely due to problems with checking. Tracer, Intrepid, Proclaim and S1812 were all amongst the most significant performers while prodigy was effective only on medium (and possibly smaller) larvae.

2001/2002 – As in the previous year, no chemical had significant effects on eggs (Table 10). In contrast to last season all chemicals were significantly better at controlling very small and small larvae reflecting better evaluating techniques. The treatments were equally effective. There were no significant treatment effects on medium and large larvae, likely due to the low pestnumbers (mean < 1) present in the field this season.

Effect on other insects

2000/2001 - Beneficial: Prodigy and Rimon showed positive affect on Coleoptera beneficial with 46% and 65% respectively better than control while Intrepid, Steward, Agrimec, Tracer and S1812 had negative but not significant affect (Table11). All chemicals tested had significantly reduced the number of ants while only Proclaim, S1812, and Tracer significantly reduced the number of spiders (Table 12). Tracer, S1812 and Intrepid had negative affect on total wasps.

Pests: Intrepid, Proclaim, Prodigy and Rimon affected thrips significantly worse than the Control while Tracer and S1812 reduced thrips but not significantly. Rimon and Intrepid reduced mirids but Tracer, S1812 and Prodigy significantly favoured them (Table 13). For total Coleoptera pest, Steward, Intrepid, Tracer and S1812 were significantly better than the control. Hemiptera pests, Agrimec, Affirm, Intrepid and S1812 were significantly better than Control while Steward, Rimon, Tracer and Prodigy did not control them.

2001/2002 – Beneficial: Tracer and Affirm had a significant effect on Coleoptera beneficial (approx. 60% higher than Control). Agrimec, S1812 and Steward negatively affected beneficial Coleoptera but not significantly (Table 14). There was no significant effect on total coccinellids by any of the chemicals tested; however, Steward, Intrepid, Agrimec, S1812, Affirm and Prodigy all reduced significant numbers of 2-spotted ladybird beetles. Only Rimon was significantly less disruptive to other Coleoptera beneficials as well as on total Hemiptera beneficials. None of the chemicals affected lacewings significantly. Affirm, Agrimec and Intrepid significantly reduced the number of spiders and Trichogramma (Table 15). Steward was significantly better i.e had less of an impact on Trichogramma and total wasps while Intrepid significantly reduced total wasps. No significant treatment effects were found against ants, lacewings.

Pests: Tracer, S1812 and Affirm significantly reduced thrips numbers (Table 16). Prodigy and Agrimec performed equal to the controls while Rimon and Steward flared thrips numbers but not significantly. Intrepid, Agrimec and Affirm were significant in reducing the number of jassids while Prodigy, Steward, Rimon and Tracer performed significantly worse than Control. Rimon had a significant effect on mirids (42.08%). Affirm, Intrepid and Steward performed equal to Control while Prodigy, S1812 and Tracer did not control mirids. Agrimec significantly favoured mirids. For total Hemiptera pests, Intrepid, Agrimec, Affirm and S1812 were significantly better than Control while Rimon and Tracer were significantly worse.

1. OLD CHEMICAL GROUPS – EFFECT ON *HELICOVERPA* SPP. AND OTHER INSECTS

Effect of Variety

Variety was not significant in controlling eggs but it was highly significant for controlling larvae (Table 1). Ingard plants had significantly fewer larvae than conventional plants. This effect was anticipated due to the Bt toxin incorporated in the Ingard variety. The Ingard effect overshadowed any treatment effects at the early stage of cotton development.

Effect of Treatment

Analysis over both varieties: Chlorpyrifos had a significant effect on the number of eggs giving a 67% increase over the control treatment (Table 2). This was possibly due to its detrimental effect on predators. Thiodicarb + PBO and Thiodicarb were consistently the most effective chemicals for larval control. For very small and small larvae, Thiodicarb + PBO and Thiodicarb performed significantly better than Chlorpyrifos and Methomyl which were not significantly different from the Control. However, a significant variety/treatment interaction (F=0.009) was found indicating that treatments may be effective in conjunction with Ingard. This is more likely to occur in the later stages of crop development. For medium larvae, all treatments except Deltamethrin were significantly better than Control. For large larvae, both Thiodicarb and Chlorpyrifos were the only significant treatments. The interaction (F=0.017) again indicated that treatments may work in conjunction with variety. Chlorpyrifos on its own was in most cases the worst treatment.

Analysis of Conventional variety only: None of the chemicals tested was effective against eggs, however, all treatments were significant in the control of larvae (Table 3). Thiodicarb + PBO and Thiodicarb were the most effective compounds when ranked especially in the control of large larvae.

Effect on other Insects

Chlorpyrifos, Deltamethrin, Methomyl and Thiodicarb also controlled aphids, jassids and beetles and had a significant detrimental effect on predators (Tables 4, 5, 6). Thiodicarb + PBO significantly affected beetles, apple dimpling bugs and predators while none of the compounds had any effect on mirids. The only chemical effective against thrips was Deltamethrin.

2. BIOLOGICAL CHEMICALS – EFFECT ON *HELICOVERPA* SPP. AND OTHER INSECTS

Effect of Variety

The variety effect was very strong for all larvae but insignificant for eggs. Ingard plots had significantly fewer larvae than conventional plots (Table 17). The *B*t toxin needs to be ingested by larvae, hence the lack of effect on eggs.

Effect of Treatment

Analysis of Conventional variety only: 2000/2001 - Results show that brown eggs were the only stage of Helicoverpa affected by treatment (Table 18). Foliar *Bt* had significantly more eggs than Control. Azadirachtin, NPV and Spinosad also increased brown egg numbers but not significantly. MPV 2 was the only treatment that reduced brown egg numbers. Foliar *BT*, as well as other biological agents generally do not affect eggs so the results have been distorted by other errors (possibly counting errors in the field). There were no significant effects on larvae.

2001/2002 – Tracer was the only treatment that significantly reduced medium larvae, (Table 19). It was used as a standard and also proved most effective for control of larvae in other trials. During this season treatment effects on medium and large larvae were most likely influenced by the low insect pressure experienced. Very few medium and large larvae were counted in the field during the season and therefore, many effects have not been expressed.

Effect on other insects

2000/2001: All treatments were significantly affecting apple dimpling bugs(Table 20). Azadirachtin plus oil, NPV and Tracer had significantly less apple dimpling bugs than Control while Foliar Bt and MPV2 had higher numbers. The result for NPV is suprising as it should mainly affect Lepitoptera. Tracer was the only treatment that significantly reduced thrips numbers when compared to control. For total Hemiptera, all treatments had significantly higher number than Control. Tracer, Azadirachtin + oil and MPV2 had significantly lower numbers of Coleoptera pests than Control. Again, the result is understandable for Tracer and Azadirachtin (Industry Standard and non-selective biological insecticide) but not for MPV2 which should primarily affect Lepitoptera. All other insects not listed here were not significantly affected by the biocontol agents (see Appendix III for complete list). So in general, these agents showed limited ability to control pests in cotton (except for Lepitoptera).

2001/2002: There were significant treatment effects on ants, spiders, wasps, lacewings, Coleoptera pests, jassids, mirids, thrips and hemiptera pests (Tables 21, 22). Results from this trial are affected by a number of factors:
- very low *Helicoverpa* numbers this season
- consequently lower predator and parasite numbers
- certain chemicals showing effectiveness against groups that they usually do not target.

There were no significant effects of any chemical on wasps. However, it should be noted that the mean number of wasps throughout the season was 0.1 wasp per metre per sample date. Azadirachtin significantly reduced Hemiptera and Coleoptera pests, jassids and mirids but left significantly higher numbers of ants. It also reduced wasps and lacewings, but not significantly (non-selective to insects). NPV and *Bt* both significantly reduced jassids and mirids, likely due to the positive effect they had on predators. Tracer significantly increased Hemiptera pests and thrips.

Comparison between the two seasons

When looking at the number for insects for the past two seasons, it becomes obvious that insect numbers per metre are very low. It is suspected that the low insect pressure over the last two seasons is the primary cause of some unexpected effects and hence the true effects of these chemicals may not be fully reflected in these experiments. This justifies why this type of monitoring needs to be carried out on a continual basis and cannot be used sporadically.

7. Provide an assessment of the likely impact of the results and conclusions of the research project for the cotton industry. Where possible include a statement of the costs and potential benefits to the Australian cotton industry and future research needs.

These results will contribute to a reduction in the use of non selective insecticides by providing detailed information on the placement of newer chemistry in the Integrated Pest Management programs. By knowing more information about the effect of chemicals on beneficial, growers can make better decisions regarding the use of chemicals to minimise their impact on beneficial insects. In this way, the number of sprays per season can be reduced and therefore production costs may be reduced. Further, knowing more detailed information about certain chemicals assist in monitoring for resistance problems. Environmental benefits from reduced spraying should also be considered.

8. Describe the project technology (eg. commercially significant developments, patents applied for or granted licenses etc).

Not applicable

9. Provide a technical summary of any other information developed as part of the research project. Include discoveries in methodology, equipment design, etc.

During of this project we were able to refine the operation of the custom designed eight-line sprayrig. This prototype sprayrig is being used as a model for building an eight-line sprayrig for Queensland Department of Primary Industries (QDPI) for research purposes. The rig enables application of eight chemicals in one run. The operator can prepare up to eight chemicals at one time and when finished wash the rig once. The benefit of this sprayrig in this type of trial work reduces soil compaction, labour, time and operational costs.

10. Detail a plan for the activities or other steps that may be taken:
- to further develop or to exploit the project technology.

Regarding the sampling techniques, there is little refinement needed. The techniques of bugchecking, d-vaccing and leaf washing have been designed over the years to maximise the detection of every type of insect found in a cotton field. Visual checks evaluate *Helicoverpa* spp. and other Lepidopteran; suction samples capture predators, parasites and any other insects that are very mobile while leaf washes give fairly accurate estimates of the number of thrips, mites and aphids present on the crop.

- for the future presentation and dissemination of the project outcomes.

This information will continue to contribute to the education of growers and consultants through the IPM education program run by CRC. Data will also assist in the collation of information for the IRM beneficial data update published annually as part of the IPM strategy for cotton growing. Some of the information will be published in the Cottongrower magazine before the end of 2002. Scientific paper/s to be published from these trials in the near future.

11. Are changes to the Intellectual Property register required?

No

Part 4 – Final Report Plain English Summary

Introduction of *Bt* cotton varieties have allowed growers to change the insecticide use strategy for the management of *Helicoverpa* spp., the major pest of the cotton crop in Australia. However, farmers still need to use insecticides to control *Helicoverpa* spp. in the conventional varieties as well as in the later stages of Ingard varieties.

Variety played a major role in trials carried out in 2000/2001 and Ingard varieties generally showed less numbers of *Helicoverpa* larvae. Treatment effects often became significant later in the season as the efficacy of Ingard varities declined. Old chemical groups still significantly reduced the number of larvae but also reduced non-target insects. The new chemical groups showed good control of *Helicoverpa* spp. and were also softer on beneficial. However, some of the new chemicals wich claims to be soft option chemicals had quite detrimental effects on beneficial. The effects of biological chemicals were unclear due to low pest pressures throughout the trial.

Continual testing of 'old' and 'new' insecticides provides essential data that will assist in placement of these insecticides in the Integrated Pest Management (IPM) and Integrated Resistance Management (IRM) programs. This will provide regular monitoring of the efficacy of these insecticides on the target pest and their effect on other pests and beneficial insects.