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KEY POINTS:

- **Adoption of an Integrated Approach (IPM)**
- **Follow industry guidelines for Resistance Management**
- **Use a Consultant**
- **Optimise costs according to seasonal conditions**

Management of insect pests in cotton is very intensive and calls for highly skilled management. Insecticide inputs constitute one of the major costs associated with cotton production.

An Integrated Pest Management (IPM) Approach

IPM provides a basis for establishing a whole farm approach to insect management. It is the central theme for this chapter.

IPM for cotton is a system that integrates all available, practical means of managing pest populations with the aim of reducing insecticide use while maintaining or improving profitability, yield, fibre quality and crop maturity. An operational definition of IPM developed by the FAO indicated that:

- the presence of pests does not automatically require control measures as damage may not be significant
- when pest control measures are deemed necessary, a system of non-chemical pest methodologies should be considered before a decision is taken to use pesticides
- suitable pest control strategies should be used in an integrated manner and pesticides should be used appropriately.

While integrated pest management is nothing new, it is the best strategy to adopt to reduce the overall number of pesticide applications. Essentially, pest and predator numbers are carefully monitored and when pest populations exceed threshold the most appropriate selective insecticide is used for control.This approach aims to minimise predator mortality so that the insecticide is not the only factor operating to maintain the pest numbers below threshold.

Use a consultant

While it is not critical that new growers immediately become proficient in insect pest management, it is important they obtain the services of an experienced consultant.

Crop consultants will be able to provide detailed information on cotton production methods, and will have well developed strategies for the management of insect pests. A consultant should check the crop every 2 or 3 days to assess insect populations. When control is warranted the consultant will suggest the best insecticide to use, in consideration with the principles of IPM and the Insecticide Resistance Management Strategy guidelines. Your consultant will also be able to help you implement more strategic insect management such as use of trap crops and assess pupae destruction requirements and practices.

Growers should engage a consultant and discuss insect control strategies well before planting. Regular contact and communication during the season should inform the grower of any insect control problems and crop progress.

Most consultants provide detailed crop management services other than just those involving insect monitoring and control. These services are usually provided on a contract basis for the full season. Approximate costs range from $30 to $50 per hectare.

Growers should also discuss and budget their anticipated chemical requirements with both their consultant and their agricultural chemical supplier.

Growers who would like to do their own pest monitoring should consider doing a cotton crop checking course at a TAFE College or consider the IPM short course run by

Intervention with broad-spectrum synthetic pesticides is seen as a last resort, when pests exceed thresholds and there are no effective selective managements options available.

Australian Cotton CRC (contact your local cotton IDO or DA). However, it would be advisable to use a consultant for the first year at least.

Since insect control costs make up a large proportion of production costs growers should take an active interest in insect management decisions with their adviser.

Thresholds are important

Insect thresholds have been developed as a guide to determine the need for control. Using lower treatment thresholds than recommended in the Cotton Pest Management Guide will not necessarily increase yields. However, lower thresholds usually increase the number of sprays, insect control costs can escalate, and insect resistance will be exacerbated. Standard thresholds are given in the table below. Growers are also encouraged to use the IPM guidelines provided in the Cotton Pest Management Guide (available from your local DPI / NSW Agriculture office) or in EntoPAK (available from the Aust Cotton CRC's Technology Resource Centre). The guidelines are also available from the Cotton CRC website www.cotton.crc.org.au / Publicat / Pest. These guidelines suggest using dynamic thresholds that vary with crop progress.

Research on heliothis thresholds has been ongoing for many years but only a few trials have been done under dryland conditions. Research by Dallas Gibb at Moree and by CSIRO at Edgeroi indicate that insect thresholds recommended for irrigated crops are quite conservative when used for dryland crops. In general, higher heliothis larvae numbers, particularly during the pre-flowering stage of growth can be tolerated under dryland conditions without reducing yields.

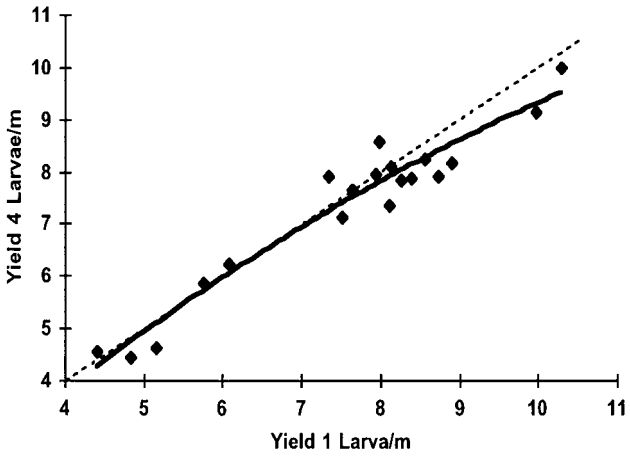
These thresholds should be used as a guide only. Thresholds may need to be varied up or down depending on damage levels and the effects of other pests such as green mirids (**Table 37**).

Figure 19 Shows there is no difference in yield between crops managed with 1 larva / m and 4

Table 37: Standard Heliothis Thresholds (No./m).

	Phase I	Phase II	Phase III
Brown eggs	-	5	-
Very small & small	2	3	2
Medium & large	1	0.5	1
Total Larva	2	3	2

Figure 19: Yield comparisons for crop managed using pre-flowering threshold of 1Lava versus 4 Lavae/m.



larvae / m at normal dryland yield levels. (Dallas Gibb pers comm).

Insects cannot tell the difference between irrigated crops and dryland crops when moisture stress is not present, but in many seasons moisture stress will make the dryland crop less attractive to insects. The lower humidity of dryland crops also reduces the survival of many insects.

In most seasons water stress will limit the yield potential of dryland cotton. Plant compensation for the loss of early squares is considered to occur at yields less than 5 to 7.5 bales / ha (depending on variety). Few dryland crops exceed these yield levels so compensation for some square loss is likely. With high levels of heliothis damage maturity can be delayed. For example up to 7 days delay in maturity has been recorded when 60 squares per metre were removed (this equals about 6 heliothis larvae per metre). But only slight differences in maturity are likely when comparing normal thresholds with low thresholds.

Dryland principles

The insect management strategy must be closely related to soil moisture status, insect pressure and realistic yield expectations. Generally aim to protect those fruit for which there is adequate moisture to produce mature bolls. Cotton has an indeterminate fruiting habit that enables it to keep producing fruit until some stress stops it. At yields below 5 bales / ha most cotton varieties can compensate for some insect damage. Varieties such as Siokra 1-4 can compensate for early insect damage very well and all "okra" leaf varieties have some tolerance to heliothis and mites.

Cotton Insecticides

Insecticides will be the major method of insect control for cotton. Insecticides are scheduled according to toxicity to humans, and growers should follow the handling and mixing instructions carefully to avoid the risk of poisoning.

There are a large number and type of insecticides registered and used to control pests in cotton. The Cotton Pest Management Guide, available from NSW Agriculture and QDPI offices, is an excellent source of information on pesticide recommendations.

A strategy to minimise the development of resistance to insecticides, miticides and transgenic cotton in northern NSW and Queensland is prepared each season and should be closely followed. Details of the current strategy are available from NSW Agriculture and QDPI offices. It is reviewed before the start of each season, and growers will need to keep themselves informed of any changes that occur.

While 5 to 10 insecticide sprays can normally be required during the course of the growing season for conventional varieties, under very high pest pressure 15 or more insecticide sprays may be required. Ingard® varieties will require approximately half the number of sprays for heliothis.

All growers also have the option of using CottonLOGIC to assist with their pest management decision making and record keeping.

Insecticides in IPM

Insecticides have been ranked with a "Beneficial Disruption Index" (BDI) according to their impact on beneficial insects. This can help to optimise their use in an IPM strategy.

Insecticides range from 'soft' (those that control target pests with little negative affect on beneficial insects) through to 'hard' (those that control the target pest and have a significant affect on beneficial insects).

Some insecticides are moderate in their affect on beneficial insects because they may have little negative affect on some beneficials but a greater affect on others.

For this reason it is important to consider the selectivity of the insecticide when deciding what pesticide to use to control the pest.

for more detailed information refer to IPM Guidelines support Document No.1, in EntoPAK. Available from the Cotton CRC Technology Resource Centre. Contact Dave Larsen 0267 991534. It is also available on the following website: http://stage-mv / Assets / PDFFiles / IPMGL99 / IPMSD01.pdf

BIOLOGICAL INSECTICIDES

A number of products containing Bacillus thuringiensis (termed Bts) as well as Heliothis viruses are registered for use in cotton. These products basically consist of solutions or powders derived from bacterial cultures or in the case of Heliothis viruses - Gemstar and Vivus, a suspension of virus particles. When used as directed, these products will selectively control plant feeding caterpillars such as heliothis larvae. Because of their unique properties they have an important role in the Integrated Pest Management programs developed for the Australian cotton industry.

Bts and Heliothis viruses have no effect on beneficial species such as predators and parasites. Therefore when used during early season (Stage 1) they can allow numbers of beneficials to build up at similar rates to unsprayed cotton.

Bts and Heliothis viruses used in combination with other insecticides later in the season e.g. thiodicarb, endosulfan and the synthetic pyrethroids (SPs), can help reduce the selection of pests with resistance to those chemicals.

Bts and Heliothis viruses are particularly good products for use near waterways, houses, or other environmentally sensitive areas. They have no contact activity and are active only after the caterpillar ingests them. With Bts the larvae stop feeding within minutes of ingesting the treated plant material, and cause no further damage to the plant. Bts cause the stomach wall of the larvae to breakdown causing death due to starvation, septicemia, and toxic shock. Sick and dying larvae can usually be found in the treated crop for 2-4 days after spraying. Death can be quicker under dry, hot conditions as the larvae desiccate at a faster rate.

Heliothis viruses are more slow acting than Bts or many conventional pesticides. They infect the larva and rapidly multiply within it. The dead larva can sometimes transfer the disease to other larvae thus perpetuating the infection in the field particularly when conditions are favourable.

Performance of Biological Sprays

Timing. Biologicals are most effective on hatchlings and very small larvae. Sprays are ideally timed to coincide with the brown egg stage of development or at hatching larvae.

Crop Coverage. Thorough coverage of the main larval feeding sites is essential as the material needs to be ingested.

Environmental Conditions. If possible, apply when larvae are actively feeding, and when there is low exposure to UV light - preferably early evening or night. Recent research on the application of Gemstar did not find significant difference in performance when applied in the morning although there was a trend toward better performance when applied in the evening. Addition of milk powder improved activity in some situations. Additional wetting agents or stickers may be required to improve product performance under rainy conditions. **Read the label for directions.**

Rate. Best results are obtained at the higher registered rate, particularly if the biological is to be used alone.

Growers must be aware that use of Bt sprays is not permitted on conventional sprayed cotton that is designated as an Ingard® refuge. However Heliothis viruses can be used at any time on sprayed Ingard® refuges.

Ingard® For Dryland

Ingard® is a plant produced protein insecticide that is purchased on a green hectare basis. A range of dryland adapted cotton varieties that produce the Ingard® insecticidal protein are available. Trials and commercial areas of Ingard® were first grown dryland in the 1996-97 season and results were generally good. Expression of the Ingard® protein does not appear to be diminished by moderate moisture stress however the economics of using Ingard® in a rain fed environment need to be carefully assessed.

Pricing based on green hectares has made Ingard® a more attractive option for growers using skip row configurations.

The high early fruit retention sometimes provided by Ingard® can cause crops to cut out more quickly. This can mean a yield disadvantage if rain patterns suit later maturing crops.

Ingard® crops make it easier for growers to adopt an integrated approach to pest management.

SECONDARY PEST MANAGEMENT

Many insect pests other than heliothis infest cotton and have the potential to reduce yield and quality. Mites, aphids, thrips, mirids and tipworm are some of the more common secondary pests.

Mites are seldom a problem in dryland crops but should be carefully monitored as they can reduce yield and quality significantly if they establish a significant population before February.

Aphids are often found in the crop from emergence onwards. They can develop very high populations but are generally easy to control. Resistant strains of aphid are now present so care should be exercised where a spray failure has been detected. Aphids have also been linked to a new disease of - Cotton Bunchy Top. Early heavy infestations of aphids should be controlled if bunchy top is considered to be present. Normally cotton can tolerate quite high numbers but once cotton bolls begin to open, aphids should be managed so that there is no risk of honey dew production. Honeydew contaminated lint has large price discounts and its presence could ruin Australia's reputation as a supplier of high quality cotton.

Thrips are a pest of seedling cotton but only require treatment if damage thresholds are reached. While thrips can damage early leaf growth and make a crop look unattractive, research continues to show that early leaf damage will not affect crop yield or maturity. An exception to this may be in cooler season areas where the combination of leaf damage and cool nights may restrict plant growth. Commonly used seed treatments give good short term control of thrips. (Thrips are excellent mite predators and early flaring of mite numbers is usually associated with situations where the use of certain pesticides has eliminated thrip populations)

Mirids can be a problem in dryland cotton. They are often difficult to detect in the field, and monitoring square retention or the rate of square number increase is an important consideration when deciding if control is necessary. Applications of organophosphates and pyrethroids have been regarded as the most effective control methods but can be very disruptive to beneficials. New products such as Regent® can be used to reduce the impact on beneficials. Endosulfan can also been used to suppress light - moderate mirid populations.

Tip worms are usually present in low numbers every year and are often mistaken for heliothis larvae. Tip worms sometimes occur in very large numbers following cool wet winters and have the potential to cause severe damage to the cotton growing tip and squares. Large numbers of the pest's distinctive eggs can be

used to alert growers before the larva cause excessive damage. Once the tip worm larvae become entrenched in plant tissue chemical control is usually ineffective. Ingard® cotton provides very effective control of tip worms.

For current insecticide recommendations please refer to the *Cotton Pest Management Guide.*

MANAGING INSECTICIDE RESISTANCE IN HELIOTHIS

Key Strategy Guidelines

1. Cultivate cotton and alternative crop residues as soon as possible after harvest to destroy over wintering H. armigera pupae. Cultivation must be completed before the end of August.

2. Use recommended larval thresholds to minimise pesticide use and reduce resistance selection.
Refer to the current *Pest Management Guide for Cotton*. Monitor first position fruit retention. If egg numbers will produce a larval population greater than the recommended threshold, target sprays on newly hatching larvae.

3. Monitor 1st position fruit retention pre-flowering. Aim to retain around 60%.

4. Avoid using broad spectrum sprays - such as organophosphates or pyrethroids early in the season. They reduce the numbers of beneficial insects and increase the chance of mite and aphid outbreaks.

5. Monitor mite populations regularly after seedlings emerge. If established mite populations are present (>5 to 10% of plants infested) avoid using broad spectrum insecticides to control other pests (see 4). Instead use selective compounds or compounds that also control or suppress mites, either alone or in mixtures as required.

6. Avoid continuous sprays of any one chemical group, including Bt products. (Rotate between chemical groups where possible). Do not exceed the maximum acceptable use limits indicated on the Cotton Resistance Management Strategy chart.

7. Do not respray an apparent failure with a product of the same group - unless the failure is clearly due to factors such as poor application or timing, etc.

8. Control weeds on farm to minimise hosts for mites and other pests, particularly in the winter-spring period.

9. Comply with any use restrictions placed on insecticides used on crops other than cotton for the purposes of managing resistance.

For future reference go to the Cotton CRC website: *www.cotton.crc.org.au*, then click onto Publications then click onto Insect Resistance Management Strategy, or refer to the current *Pest Management Guide for Cotton*.

To be on the Cotton Industry mailing list please contact Dave Larsen 02 6799 1500.

CottonLOGIC

by Dave Larsen

CottonLogic, the latest management tool available to cotton growers to help them with their cotton farming decisions, was developed by a team of researchers at CSIRO Plant Industry.

It is distributed for free by the Australian Cotton Cooperative Research Centre.

Information on insect pressures, crop inputs, pesticide applications, field operations and much more can be stored and easily accessed. This information can then be used to make decisions to improve cotton crop production and sustainability.

It incorporates:

- EntomoLOGIC- A pest management decision support system. As well as data entry, storage and reporting it contains the following insect models:
  - Helicoverpa life cycles - predicts pest pressure for the next 3 days
  - Mite models - predicting mite pressure, yield loss and predicted date over threshold

  These models provide information to the user for a more informed decision and better pest management.
- NutriLOGIC for irrigated crops - Analyses soil and petiole nitrate tests and gives nitrogen recommendations to maximise yield. Use on irrigated crops only
- Support for Rotation and Refuge crops
- User-Definable INGARD® Thresholds
- Weather Data Entry for Operations
- Forecast Temperature Data Entry for more accurate Helicoverpa pressure prediction
- A comprehensive range of cotton pest and beneficial insect pictures and information
- Helicoverpa diapause model, predicting the number of pupae entering diapause and their expected re-emergence dates

Why use CottonLOGIC?

Supports the 3 industry sampling methods (numbers per metre, numbers per plant and presence / absence sampling methods).

- Supports INGARD® thresholds
- Supports plant mapping techniques.
- The insect thresholds for the various cotton pests are user definable to suit their own management strategy.
- CottonLOGlC is also a valuable record keeping system for all agronomic data. Information on insect pressures, crop inputs, pesticide applications, field operations and much more can be stored and easily accessed.
- CottonLOGlC allows growers to check the status of a whole farm to determine where pests are most prevalent and how they are being controlled.
- CottonLOGIC is a computer software package that will help with farming decisions, in particular for insect pests.
- CottonLOGIC enables the user to browse a series of insect pictures at various stages of their life cycle.

As insecticide resistance increases, pest management decisions are becoming increasingly complex and costly.

As well as providing valuable information for decision-making, CottonLOGIC can store information about insect checks, sprays, irrigations, crop planting and development rates, fruit counts, yields, plant maps and much more. For example, by keeping records of sprays and insect pressures, growers and their advisers can review the performance of pesticide applications.

Consultants can provide additional information to growers in the form of end-of season or progress reports. Daily summary reports indicate the status of a whole farm allowing growers to determine where pests are most prevalent and how they are being controlled. Spray records can be used to ensure that resistance management guidelines are followed to minimise pesticide resistance.

CottonLOGIC software for insect management is now available for the Palm Operating System for use on handheld devices. This system has been designed to help in-field decisions and to streamline data entry.

Maximising Yields

CottonLOGIC has been used over a number of seasons in large scale trials on irrigated and dryland cotton farms. Excellent results have been obtained using CottonLOGIC's standard thresholds and both conventional and selective insecticides. This work has also identified ways to reduce dependence on pesticides by maximising the benefit of predatory insects.

By using the standard thresholds growers can minimise sprays while maintaining yield and earliness.

The advantage of using thresholds is that sprays can be scheduled according to the insect pressure - a spray is recommended whenever insects are over the threshold but can be delayed under conditions of low pest attack.

Protecting Dryland Yields

Much debate has surrounded insect management on rain-grown cotton. Excellent yields have been achieved in rain-grown crops using CottonLOGIC with standard thresholds. In comparative trials, cotton managed using CottonLOGIC achieved the same yields as commercial plots.

Pesticide sprays are the major variable cost in dryland cotton production. Therefore pest management decisions can have a higher impact on farm profits than in irrigated cotton.

CottonLOGIC PC System Requirements:

- Windows 95, 98, 2000, NT, ME / XP.

(CottonLOGIC has been run on Macintosh PowerPC in conjunction with soft windows)

- A Pentium or 486 with at least 32MB RAM
- 256 colour screen for insect pictures
- 17Mb of disk space for complete installation

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