CHAPTER 12

Integrated insect and mite management

By **JAMES HILL**

Lewis Wilson and Sandra Deutscher (CSIRO), Robert Mensah and Annie Johnson (Industry & Investment NSW).

What is integrated pest management (IPM)?

IPM involves using all means of managing pest populations with the aim of reducing insecticide use whilst maintaining profitability (yield, fibre quality and crop maturity). IPM is a whole year approach to managing pests.

Why do we need to develop IPM programs?

Over-reliance on synthetic insecticides creates problems, such as insecticide resistance of the major pests (particularly H. armigera), disruption of natural enemies of the pests leading to outbreaks of secondary pests such as mites, aphids or whitefly and other environmental consequences. These problems have cast doubt over the long-term viability of the traditional insecticide dominated approach to pest management.

A major goal for the cotton industry is to reduce dependence on foliar and soil applied insecticides. This can be achieved by developing an IPM program that integrates a range of pro-active management tactics, especially the conservation and use of natural enemies (predators and parasites) to control pests.

How do we implement IPM?

IPM involves integrating a range of tools and strategies for managing pests. These can be conveniently grouped in seven main objectives:

- Growing a healthy crop;
- Keeping track of insects and damage;
- Preserving beneficial insects;
- Preventing insecticide resistance;
- Managing crop and weed hosts;
- Using trap crops effectively; and,
- Communication.

KEY POINTS

- Integrated Pest Management (IPM) aims to reduce insecticide use but maintain profitability.
- IPM is a whole year approach to managing pests.
- Adhering to your IRMS strategy is one way to help manage insecticide resistance.
- For further information and support in carrying out integrated insect and mite management refer to the IPM module in myBMP.

Growing a healthy crop

This objective covers the key issues for good crop agronomy and highlights how they interact with IPM.

Growing a healthy cotton crop optimises both its yield potential and capacity to compensate for pest damage.

Field selection

When selecting fields for planting cotton consider proximity to sensitive areas such as watercourses, pastures, buildings, and the prevailing wind direction. Bollgard II® varieties may be appropriate for fields near sensitive areas. Another consideration would be the proximity of these cotton fields to other crops or orchards which can potentially act as a source for secondary pests such as mites, aphids or whitefly.

Seed bed preparation

A tactic often mentioned by cotton growers in achieving an early crop is a good seed-bed which helps achieve vigorous, healthy, early growth that tolerates seedling disease better and achieves early crop maturity and high yield potential.

Selecting a variety

The cotton varieties planted should be matched to the region and likely pests and diseases (see CSD variety guides or websites). Select a variety that suits the growing region in terms of length of season. Shorter season varieties may also be considered as the shorter growing period reduces the time the crop needs to be protected from pest damage.

Bollgard II® cotton is ideally suited to IPM as the level of control of Helicoverpa spp. provided by the plant is usually sufficient to dramatically reduce the need to spray for this pest or other lepidopteran pests such as tipworm, especially early season.

Planting window

In each cotton region there is a period when soil temperatures become suitable for cotton germination, 14°C minimum at planting depth. Planting at this time usually maximises plant establishment and avoids the risk of cold shock (night temperature < 12°C). Cold shock slows early growth and reduces tolerance to herbicides, seedling diseases and early pests, especially thrips. Very late planted cotton has less yield potential and is more susceptible to pests such as whitefly and late season

infestations of H. armigera both of which are difficult and expensive to control.

In areas susceptible to whitefly, coordinated planting windows can provide a period free from host crops to reduce population build up as well as preventing late crops. The 42 day planting window for Bollgard II® cotton is a critical component of the resistance management plan.

Optimising water and nitrogen

Adequate water and nutrition will ensure healthy growth of plants that are more tolerant of pests and diseases. Too much nitrogen creates excessive cotton growth toward the end of the season and perhaps even the need for an extra irrigation. This makes the crop more attractive to pests, requiring additional inputs of insecticides (and mixtures of insecticides) for control, and application of high rates of growth regulators to retard growth.

Growth regulators

Excessive vegetative growth is a problem because it reduces the retention of fruit and delays maturity. Rank growth of plants also results in reduced efficacy of insecticides due to poor penetration of the canopy.

The CottASSIST Cotton Development Tool can calculate vegetative growth rates to determine crop needs. (www.cottassist.cottoncrc.org.au)

Final irrigation

The timing of the last irrigation aims to ensure that boll maturity is completed without water stress, and at the same time prevent the occurrence of lush crop being attractive to the Helicoverpa spp. and other pests such as aphids and whitefly.

Defoliation

The timing of defoliation can be an important IPM tool, as late pest infestation problems can sometimes be overcome by a successful defoliation.

Keeping track of pest and beneficial abundance and plant damage

The purpose of crop monitoring is to determine:

- The pest(s) present;
- The level of infestation;
- The damage they are causing;
- The level of beneficial insects;
- Expected response to control options;
- Environmental conditions; and,
- The growth stage of the crop.

This information provides the basis on which pest management decisions are made.

Check frequently

Crops should be checked frequently (at least twice weekly) for pests, beneficials and for damage and fruit retention.

Crop scouting.

Types of sampling techniques

Visual sampling: This involves looking at the entire plant, including under leaves, along stems, in squares and around bolls.

Beat sheet sampling: A sheet of yellow canvas 1.5 m × 2 m in size is placed in the furrow and extended up and over the adjacent row of cotton. A metre stick is used to beat the plants 10 times against the beat sheet, moving from the base to the tops of the plants. Insects are dislodged from the plants onto the canvas and are quickly recorded.

D-Vac sampling can be used as an alternative to visual for sampling spiders and beneficial insects. A sweep net may be an alternative to the beat sheet when the field is wet. A D-vac is also effective in Refuge crops such as Lucerne to sample beneficial numbers.

It is generally not possible to make a decision about whether control is needed based on just one check. The decision making system needs to be flexible to allow for the action of beneficials and natural mortality..

Insect numbers should be recorded either as numbers per metre or as a percentage of plants infested to easily compare numbers with the appropriate industry threshold and to allow a predator to prey or pest ratio to be determined.

How much to sample

This will vary according to growth stage and individual factors. It is also vital to consider plant damage, fruit load, yield and maturity.

Damage monitoring includes:

- Leaf loss (up to the 6 true leaf growth stage);
- Tip damage;
- Fruit retention or fruiting factor; and,
- Boll damage.

Crop Development Tool (CDT)

Cotton development can be predicted using daily temperature data (day degrees). The Crop Development

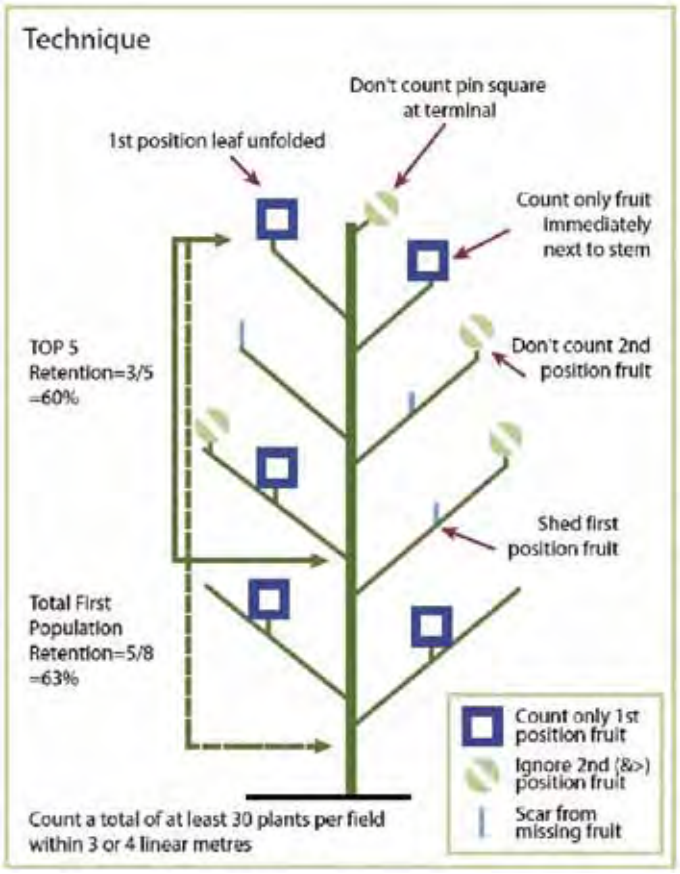
Tool (CDT) uses this knowledge to enable crop managers to check the vegetative and reproductive growth of their cotton crops compared to a potential rate of growth and development. A crop manager can use this information as a prompt to further explore why the crop may not be on track, and manage the crop accordingly. To use the CDT, access CottASSIST through the Cotton CRC website; www.cottassist.cottoncrc.org.au

First position fruit retention

Monitoring first position fruit retention is a technique that is best used from squaring to early flowering. It is a quick way to estimate early signs of insect damage (Refer to figure 1).

- Count the first position fruit on either the top five or all the fruiting branches.
- Monitor both tipped and non-tipped plants.
- Monitor only the dominant stem, not vegetative branches.

FIGURE 1.
A technique for checking fruit retention.



Aim to have first position fruit retention of 50–60% by first flower. Low retention (< 50%) increases the risk that yield or crop maturity will be affected. However, very high fruit retention, in excess of 80% may also be associated with a yield penalty.

Preserving beneficial insects

Predatory insects, spiders and parasitic insects (beneficials) consume pests. Beneficials can considerably reduce pest numbers thereby reducing the need to control pests using chemical insecticides. The abundance of beneficial insects is affected by food resources, mating partners, over wintering sites, shelter, climatic conditions and insecticide sprays. For an IPM system to work, the conservation of beneficial insects is critical. This can be achieved through the use or provision of natural or crop refuges (e.g. trees, pastures or lucerne strips).

In an IPM system which focuses on managing beneficials the following tools can be used;

- Predator/Pest ratio;
- Incorporating parasitoids into spray decisions;
- Beneficial releases;
- Food sprays;
- Lucerne strips;
- Appropriate use of pesticides;
- Beneficial Disruption Index; and,
- Petroleum spray oils (PSO) mixed with a selective or biological pesticide.

Appropriate use of insecticides

- Minimising early season sprays helps to conserve the beneficial insect population. The cotton plant has the ability to tolerate a level of damage without affecting yield or crop maturity.
- Many beneficial species frequently move in and out of cotton, other crops and non-crop habitats. It is important to manage pests on a field by field basis or by a small management unit, not an entire farm.
- Pests such as aphids or mites often infest the edge of a field, not the entire field area. It is possible to manage this type of infestation by only spraying the field borders. This enables the beneficial population to re-establish or re-build much faster.
- Some insecticides have very little impact on beneficial insects including parasitoids.

Follow the IRMS when selecting pest control options

Resistance occurs when application of insecticides removes susceptible insects from a population leaving those individuals that are resistant. Mating between these resistant individuals gradually increases the proportion of resistance in the pest population as a whole. Eventually this can render an insecticide ineffective, leading to field control failures. Resistance can be due to a trait that is already present in a small portion of the pest population or due to a mutation that provides resistance.

Management of resistance is essential to ensure that valuable insecticides remain effective, the Australian cotton industry has developed the Insecticide Resistance Management Strategy (IRMS). The IRMS is designed to prevent resistance development, while managing existing resistance. Some core principles used in the IRMS include:

- Rotation between chemical groups with different modes of action.

- Limiting the time period during which an insecticide can be used. This restricts the number of generations of a pest that can be selected in each season.
- Limiting the number of applications, thereby restricting the number of selection events.

See the Cotton Pest Management Guide for the 2010/2011 IRMS.

Resistance monitoring

Resistance monitoring for Helicoverpa spp., two-spotted spider mites, aphids and silverleaf whitefly, is conducted each year by the cotton industry and provides the foundation for annual review and updating of the IRMS. All growers and consultants have access to this industry service to investigate suspected cases of resistance.

Pupae busting

In NSW and southern Queensland, Helicoverpa spp. overwinter in the soil as pupae and emerge as moths in spring to mate and lay eggs. Known as diapause, this resting pupal state is induced by decreasing daylength and temperature in late summer. Most of the pupae which over-winter in cotton fields are H. armigera. They are likely to have a high survival rate because of the low numbers of parasites. They have the potential to carry insecticide resistance, including Bt resistance, through to the next season. Therefore, it is important to pupae bust for their control.

Pupae are likely to be found in the top 10 cm of the soil surface. Cultivate to achieve disturbance of the soil sufficiently to destroy pupae or their emergence tunnels. The tillage required for:

- 1 m hills – till the whole hill;
- 2 m beds – till across the whole bed and almost down to furrow level;
- Skip-row – till right across the soil surface.

Pupae busting Bollgard II® cotton fields is mandatory between picking and the end of July.

Web tool to assist pupae busting decisions

The proportion of pupae entering diapause increases from low levels in March to high levels, almost 100%, by late April. However the rate of diapause induction varies from season to season and region to region. Knowing when diapause is induced is useful for identifying 'high risk' fields, i.e. those fields most likely to have diapausing pupae that should be targeted for pupae busting. On the Cotton CRC website, a web tool is available to help calculate the likely rate of diapause induction for your area, based on local climate data. The tool is also able to compare the results for the current season with the long term average and hotter than average or cooler than average seasons.

The web tool can also be used to predict the rate of moth emergence from diapause in spring. This can assist in timing pupae busting operations to maximise their effectiveness. The breaking of diapause is influenced by temperature. The tool calculates the emergence percentage from the day after the threshold temperature of 18°C is reached. To use the tool go to: http://cottassist.cottoncrc.org.au/DIET/DIETTool.aspx

Trap crops and weed control

Trap cropping and weed control assists resistance management, as well as IPM, by reducing the size of the overall pest population which reduces the need to apply insecticides and reduces the selection pressure for the pest to develop resistance.

Resistance management for Bollgard II® cotton

Resistance management for Bollgard II® cotton is critical due to the season long selection of Helicoverpa spp. to the Bt toxins produced by Bollgard II®. A proactive Resistance Management Plan (RMP) has been developed to preserve the effective life of Bollgard II®.

Resistance management guidelines for all crops

Several other strategies that are relevant to cotton and other spring and summer crops can also help in managing resistance. These include:

- Avoid cross selection for resistance. Spraying for one pest can be simultaneously selecting resistance in another pest that is present, even though that pest is at sub-threshold levels and not specifically being targeted. For example, if a pyrethroid is used to control a pest other than Helicoverpa spp. Do not follow up with another pyrethroid for H. armigera control as the first spray may have already selected for pyrethroid resistant H. armigera. This applies to all insecticides which target multiple pest species.
- Selective insecticide use is preferable, consistent with the IRMS, as this helps conserve beneficial insects. Beneficials eat or parasitise resistant as well as susceptible pests.
- Ensure spray applications are accurate, timely and triggered by pest thresholds. Using plant compensation allows for the plant's capacity to recover from a degree of damage without loss, thereby avoiding insecticide applications to prevent non-economic damage.

Managing weeds and crop residues

Weed management

The potential for pests to over-winter on weeds, and infest the subsequent cotton crop early in the season, is often greatest when a mild wet winter occurs. Ideally, management of weeds, in fallow fields, cropped fields, and in the borders and headlands should be undertaken early in winter and continue through winter and spring as necessary.

Weeds provide over winter hosts for a number of pests including mites, whitefly, mirids, aphids, tipworm, cutworm and armyworm. Growing of refuge crops for beneficials, such as Lucerne, is an option available to growers who want to enhance beneficial numbers.

Managing cotton regrowth

Regrowth of cotton after harvest (ratoon cotton) provides refuge for Helicoverpa spp., spider mites, green mirids, apple dimpling bugs and aphids. Regrowth should be controlled by slashing, root pulling and/or mulching to prevent pests being carried between seasons.

Regrowth cotton is also a risk for carry-over of the disease Cotton Bunchy Top (CBT). Cotton aphids feeding on these plants could then pick up CBT and spread it to adjacent cotton crops in the following season. Cotton regrowth also has implications for managing soil-borne diseases (see the Integrated Disease Management guidelines).

Technology Users Agreements for GM cottons require the control of cotton regrowth. For more information on the requirements for managing Bollgard II® volunteers see the Cotton Pest Management Guide.

Rotation crops

Growing a range of crops can be seen as essential to providing a habitat for a variety of insects. Cotton in monoculture over a wide area provides a little opportunity for beneficials to thrive and persist.

The selection of a rotation crop has many implications for pest management. Rotation crops are hosts for a range of pests, such as mites (faba beans, safflower), aphids (faba beans, canola) or H. punctigera (chickpeas, canola). Some rotation crops may also affect carry over of disease or conversely provide a disease break as suggested in Integrated Disease Management Guidelines.

Options for managing pests in rotation crops should also be considered. With no major initiative to structure insecticide resistance management in field crops other than cotton, follow the basic IPM principle to use as many methods as possible to manage pests.

Further information on rotation crops can be found in the Crop Rotations chapter.

Faba beans.

Use trap crops effectively

Trap cropping is an IPM tactic that can be utilised on a farm level or area wide basis. Trap cropping aims to concentrate a pest population into a manageable area by providing the pest with an area of preferred host crop. When strategically planned and managed, trap crops can be utilised at different times throughout the year to help manage a range of pests. This assists resistance management as well as IPM, by reducing the size of the overall population which reduces the need to apply insecticides and reduces the selection pressure for the pest to develop resistance.

First generation or spring trap cropping

Spring trap crops are designed to attract H. armigera adults as they emerge from over wintering pupae in spring. Larvae arising from eggs laid in the crop are controlled using a biological insecticide or allowed to pupate and are controlled by cultivation. A trap crop, strategically timed to flower as pupae are emerging in spring combined with effective pupae busting in previous autumn can help to reduce the early season build-up of H. armigera in a district.

An ideal first generation trap crop is one that is; very attractive to H. armigera, is a good nursery for beneficials, does not host secondary pests or diseases, does not become a weed problem and is easy to establish and manage. Many winter crops have been trialled to measure their potential as a spring trap crop. Chickpea has consistently proven superior to all other crops in its ability to generate large numbers of H. armigera, however it is not a good nursery for beneficial insects. Chickpea has also proven to be agronomically robust, being suitable for both dryland and irrigated situations.

Growers must ensure trap crops do not become future nurseries of Helicoverpa spp., and so effectively controlling populations in the trap crop by timely destruction of the crop itself is required. Because the trap crop will not be harvested for yield, a fast knock-down insecticide is not required. Bio-pesticides like Bt and virus formulations may be well suited.

Summer trap cropping

A summer trap crop aims to draw Helicoverpa spp. away from the main crop and concentrate them in a small area planted to another crop such as sorghum. Once concentrated into the trap crop, the larvae can be controlled.

Some summer trap crops may produce large numbers of beneficial insects that can then move into nearby crops, for example, the Trichogramma spp. in sorghum and maize.

The trap crop would be planted mid season, to ensure that it was highly attractive to H. armigera late in the cotton season. The attractiveness of the cotton crop relative to the trap crop may significantly influence the potential effectiveness of this strategy.

In Central Queensland cotton growers are using summer trap crops of pigeon pea as part of the RMP for Bollgard II® cotton.

Communication

Communication with neighbours, farm workers, the consultant and the applicator is essential to develop a successful IPM program.

Pesticide application management plan (PAMP)

The core best management practice for safe and responsible pesticide use is to develop a pesticide application management plan (PAMP). The PAMP will help ensure that everyone involved in a pesticide application has a clear understanding of their responsibilities. It also helps identify the risks associated with pesticide applications so that controls to minimise those risks can be put in place.

A PAMP has two essential aims:

1. Establishing good communication with all involved in the application of pesticides. This communication is required both pre-season and during the season. It should exist between the grower, the applicator, the consultant, farm workers and neighbours.
2. Ensuring appropriate application techniques and procedures are used.

Supporting these aims is good record keeping – of each aspect of the PAMP itself, and the details of pesticide application. This record keeping is important to check the effectiveness pesticide applications, to comply with regulatory requirements and to demonstrate due diligence.

For more information and assistance in developing a PAMP refer to the Pesticide Management module in myBMP.

Area Wide Management (AWM)

AWM groups or IPM groups acknowledge that pest and beneficial insects are mobile, and that the management regimes to control pests imposed on a given field are likely to alter the abundance of beneficial insects and levels of insecticide resistance in pest populations in the surrounding locality. By communicating and coordinating strategies, AWM groups have successfully implemented IPM.

AWM for population management

AWM in the true sense primarily strives to reduce pest pressure by co-ordinating the efforts of growers in an area. The strategy is based on reducing the survival of over wintering, insecticide-resistant H. armigera pupae, reducing the early season build-up of H. armigera on a regional/district scale, and to reduce the mid-season population pressure on Helicoverpa-susceptible crops. The main tactics are spring trap crops, conservation of beneficial insects and cultivation of diapausing pupae. A critical component is to bring together farmers from a range of different enterprises, including cotton and other dryland crops. As H. armigera is a pest common to most of these crops it is vital to have all types of growers involved if AWM is to succeed.

AWM or IPM groups

These groups focus on communication and co-ordination to achieve agreed IPM goals. These may include conserving beneficials, delaying use of disruptive insecticides, reducing the risk of drift between farms and the planting of trap crops. A key element of most groups that have worked well has been regular meetings before and during the season to share information, discuss strategies and build rapport.

These guidelines are a brief version of the Integrated Pest Management Guidelines for Australian Cotton II.

FURTHER INFORMATION

IPM Guidelines for Cotton Production Systems in Australia -http://www.cottoncrc.org.au/content/Industry/Publications/Pests_and_Beneficials/Integrated_Pest_Management_Guidelines.aspx

Cotton Pest Management Guide - http://www.dpi.nsw.gov.au/agriculture/field/field-crops/fibres/cotton/cotton-pest-management-guide