

How will the drought affect *Helicoverpa* resistance management?

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The Resistance Management Plan (RMP) for Bollgard II is designed to retard *H. armigera* from developing field-scale resistance. This is obviously important for the longevity of Bollgard II.

New transgenic cottons may contain either or both of the two insecticidal genes in Bollgard II. This means that the protection of Bollgard II also represents the protection of future investment in other genetically modified cottons for the Australian industry.

During the past two seasons more than 200,000 hectares were planted to Bollgard II per year. The total area of cotton planted in the 2006–07 season will be considerably less than in previous years but the Bollgard II acreage will still represent around 80 per cent of the total area planted to cotton in Australia.

In most cotton growing regions, there has been no significant rainfall leading up to the season, and this 'dry' is likely to continue while the crop is growing. This means that non-cropping vegetation such as roadside verges which usually support larvae will be significantly reduced. In addition, in most areas there is little prospect for substantial plantings of dryland crops such as sorghum, maize and sunflowers that in a normal year also contribute non-selected moths.

As a result, *Helicoverpa* will be concentrated on the green hectares which will be mostly Bt-cotton, and there will be an increased opportunity for 'resistance genes' to increase in frequency. So it is even more critical in a drought year to abide by the obligations of the mandatory RMP.

Below we revisit some important questions around resistance management in the context of a drought year. This article is a companion to one published in the October–November 2005 issue of *The Australian Cottongrower* that examined the impact of Bollgard II on management of resistance to conventional insecticides, and answered common questions about the RMP for Bollgard II.

More technical information on the key elements of the IRMS and the RMP can be found in the 2006–07 Cotton Pest Management Guide (CPMG), which is pub-



Especially during a drought, when moths are concentrated on green hectares, pupae busting is a critical component of the strategies to control resistance by insects.

(Photo by Louise Rossiter)

lished in an electronic format on the CCC CRC Website and hardcopy available from the CCC CRC.

How do insects develop resistance?

Genes for resistance naturally occur at very low frequencies in insect populations and remain rare until they experience an environment in which they are favoured relative to individuals that carry susceptible genes. Once a selection event occurs, such as an application of a pesticide or exposure to Bollgard II, resistance genes can increase in frequency because the pests carrying them are more likely to survive and produce offspring. If selection continues, the proportion of resistant insects may increase to the point where the pest cannot be effectively controlled by that pesticide or genetically modified plant.

Will the drought reduce the population sizes of *Helicoverpa*?

The population size of the *Helicoverpa* species depends on the availability of quality hosts which is closely linked with the quantity and timing of rainfall leading up to the spring and in early summer. The breeding success during the spring and early

summer period is vital when determining the pending threat to summer crops.

In most seasons, the majority of *H. armigera* moths are locally generated. In many regions cotton is a reliable and significant host for *H. armigera* but this species uses hosts other than cotton and population sizes may be more strongly influenced by the abundance of alternative hosts.

In most years, *H. punctigera* moths migrate to eastern Australia from western inland regions, and rely heavily on non-crop hosts such as wildflowers, weeds and roadside verge vegetation. In a drought year, it is reasonable to predict reduced spring population sizes of both pest species on cotton due to the absence of suitable non-cropping hosts and reduced plantings of cultivated hosts, especially dryland crops.

Colin Tann's 2006 spring work in the Namoi valley detected early *H. armigera* activity and the increase in chickpea plantings this year within many of the cotton producing areas may assist in producing moths that will threaten cotton crops. He also recorded some breeding of *H. punctigera* after migration flights which re-

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sulted in the application of control sprays in chickpea, faba bean and other winter/spring crops.

Good quality non-cropping hosts are virtually non-existent in this valley and the control of spring crop infestations has been generally good. We expect the continuation of dry conditions to act as a brake on the build up of *Helicoverpa* populations to some degree, particularly for *H. punctigera*.

Do we need to manage resistance in a drought year?

Altered population sizes will not change the gene frequencies for resistance to conventional insecticides or Bollgard II being carried by *Helicoverpa* moths. The same proportion of resistant and susceptible moths will continue to lay eggs in cotton. So the likelihood of resistance development (that is, an increasing gene frequency) to insecticides does not decrease just because the overall size of the moth population is reduced.

Importantly, because during a drought year, populations of moths will be concentrated on green hectares, and there will be few, if any, non-cropping sources of susceptible moths, an increased proportion of the population will be exposed to cotton and thus selection for resistance. Therefore, for *Helicoverpa* it is even more important to manage for resistance to both conventional insecticides and Bt toxins in a drought year.

What is the scientific basis of the IRMS?

The IRMS aims to minimise selection

across consecutive generations of the pest. This is achieved by:

- Using 'windows' to restrict the time period that the pest is exposed to a group of chemicals;
- Restricting the number of applications of the same type of chemical;
- Rotating the application of different types of chemistries; and,
- Pupae busting and employing good farm hygiene to restrict resistant individuals surviving through winter.

Pest life cycles determine the length of the 'windows' around which the IRMS is built. As the life cycles of *Helicoverpa* species and the sucking pests are very different, a strategy applied for one will not necessarily manage resistance for others.

What is the scientific basis of the RMP?

The RMP for Bt-cotton is comprised of five components that interact to effectively slow the evolution of resistance. These are:

- Using refuges to produce Bt susceptible moths to dilute resistance;
- Limiting exposure to Bt by restricting planting dates;
- Controlling volunteer and ratoon plants;
- Restricting the use of foliar Bt; and,
- Mandatory cultivation of crop residues (or use of trap crops in northern areas).

How important is the good management of refuge crops for Bollgard II in a drought year?

The aim of a refuge crop is to generate significant numbers of susceptible moths (SS) that have not been exposed to selection by Bt proteins. As detailed above, this

production is especially critical in a drought year because there is reduced contribution of susceptible moths from non-cropping vegetation such as roadside verges and dryland crops.

Looking after refuges, including weed control, timely irrigation and all factors that make the refuges 'attractive' to female moths laying eggs, is the key to ensuring that they are effective. Managing resistance is a population level activity, and every refuge makes an important contribution to the overall RMP for the district, valley, and because *H. armigera* disperse widely, for the whole industry. Especially during a drought it is imperative that all refuges produce their quota of susceptible (SS) moths. Monsanto intend to audit the quality of refuges on every farm that grows Bollgard II to ensure that they are well maintained.

Is pupae busting still important for resistance management in a drought year?

Pupae busting is vital in a drought year because of the increased risk of resistance development. Cultivating between seasons is an effective, non-chemical method of preventing resistant pupae from surviving from one season to the next.

It is still important to pupae bust in sprayed conventional cotton because the large uptake of Bollgard II will not significantly influence the rate that *H. armigera* will develop resistance to conventional chemicals. Although we expect few larvae to survive in Bollgard II, those that do are likely to be resistant and the diapausing cohort must be killed so that the next generation of moths (emerging the following spring) are not enriched with resistant individuals.

TO SUMMARISE

- It is even more critical in a drought year to manage resistance;
- Pay particular attention to the IRMS and RMP;
- Ensure that refuges are well maintained to make them highly attractive; and,
- Pupae busting is a vital component of resistance management in a drought year.

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