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Selecting the right refuges for Bt cotton

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The introduction of transgenic cottons (Ingard) in 1996 began a new era for cotton growers in Australia. Its inbuilt toxicity to Helicoverpa moths allowed growers to use Integrated Pest Management (IPM) strategies and so reduce their use of pesticides.

But insects have a well known ability to develop resistance to chemicals used against them and laboratory studies have now shown that Helicoverpa can develop resistance to Bt.

As a major part of the resistance management plan adopted for Ingard cottons, growers must provide refuge crops on their properties. Within these, Helicoverpa can breed without any exposure to the Bt protein. Moths surviving in Bt cotton may be resistant to Bt, but moths from the refuge crop should still be susceptible. This pool of susceptible moths is then available to mate with adults produced from Ingard cotton and so help dilute selection for resistance.

The suggestion that growers actually put aside land and manage it to grow a crop attractive to pests and then let them breed there is a challenging concept. That it is happening demonstrates the confidence the cotton industry has in its scientists and the willingness of growers to implement methods that will ensure the long-term sustainability of their industry.

One aim of CSIRO's research on Helicoverpa has been to quantify changes in population levels associated with the introduction of Ingard cotton. Continuation of these ecological studies will be important to determine appropriate management strategies for the future.

Knowledge of the population ecology, movements and mating habits of Helicoverpa has enabled simulation models to be developed that predict the development of Bt resistance in the field and define resistance strategies.

Models developed by Rick Roush in Adelaide and the team in Narrabri can calculate the number of

Weed invasion following seed-mix refuge.

FIGURE 1: Abundance of Helicoverpa in Ingard cotton and a range of refuges

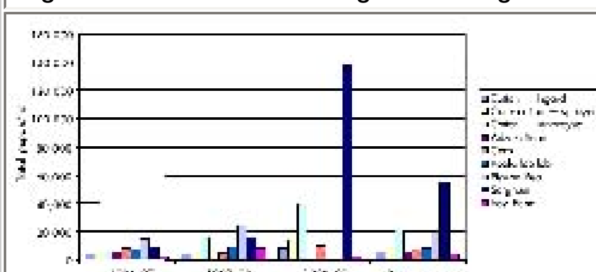


FIGURE 2: Seasonal abundance of live Helicoverpa pupae in Ingard cotton and associated refuges, 2000–01 season

hectares of refuge crop options required for every 100 hectares of Ingard cotton and also how close these need to be to the transgenic crops. Ingard is restricted to 30 per cent of all cotton plantings.

The refuge strategy assumes resistance genes are at a low frequency in natural populations and random mating occurs between individuals from refuge and Ingard crops. By producing large numbers of susceptible moths that can mate with the few resistant ones that develop, refuges will slow the rate at which resistance may emerge and consequently help prolong the technology for the future.

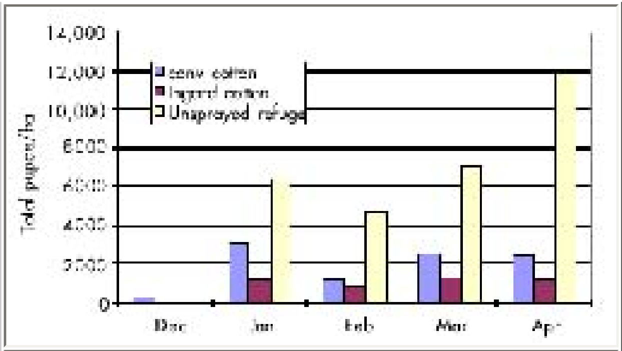
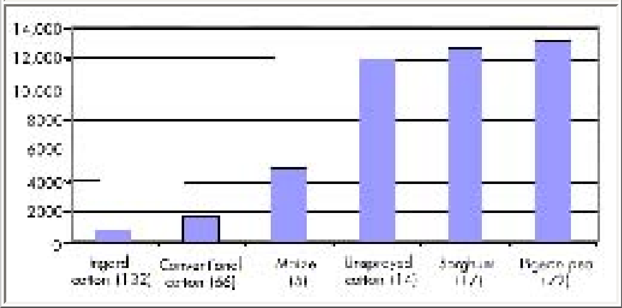


FIGURE 3: Average densities of live Helicoverpa pupae under Ingard cotton and a range of associated refuges, 2000–01 season



REFUGE OPTIONS

One challenge has been to identify refuge options that are economically and logistically feasible. Choices for refuges for irrigators include sprayed conventional cotton or four main unsprayed crops (conventional cotton, sorghum, maize and pigeon pea).

Dryland growers are restricted to cotton — either unsprayed or conventionally sprayed — due to uncertainties with soil moisture for planting. The main criteria defining effective refuges are that they should not be sprayed with Bt toxins and that they need to generate enough susceptible adult Helicoverpa to ensure matings between two resistant survivors from a transgenic crop are extremely unlikely.

Studies of Helicoverpa moth movement in agricultural regions over many years have shown that they are very mobile, both locally and through long range migrations. So the diversity and attractiveness of crops in any one agricultural region will influence the continued presence of moths there. Close proximity of refuges to transgenic crops should increase the chances of desired random mating between different populations.

Jungle effect in a seed mix refuge.

One unusual refuge option explored several years ago was the combination of a number of attractive host plants, in equal proportions, in a seed mix. This mixture, which included soybean, mung bean, pigeonpea, corn, sorghum, cotton and niger, was then combined in varying proportions (up to 30 per cent seed mix) with the summer-growing legume, dolichos lab-lab. This latter plant is used essentially as a green manure crop and does not generally set seed in the major cotton growing areas as the onset of cool temperatures and frosts in autumn prevents it doing so.

All the plant types in the seed mix established, flowered and matured successfully, although the cotton and niger were generally poor competitors with the other plants. Importantly, the seed mix was able to generate an effective refuge throughout the cotton growing season, with some plants self-sowing.

But in most treatments, the dolichus lab-lab eventually smothered and overwhelmed the seed mixture plants with its large biomass. Unfortunately, the concept of mixing these various attractive host plants with dolichus lab-lab did not prove practical because it created a significant weed problem the following season.

Later work focused on individual crops as refuges and demonstrated that pigeon pea and unsprayed conventional cotton are the most useful as refuges because they consistently produce large numbers of moths over a long period. Refuges such as corn and sorghum, although very attractive to moths which lay large numbers of eggs on them, require multiple plantings to make them available throughout the cotton-growing season and so be useful as refuges.

The effectiveness of refuge crops will, of course, be influenced by the many natural mortality factors acting on Helicoverpa populations. Parasites and predators will remove eggs, larvae and pupae, while naturally occurring diseases such as viruses can also be active in some crops.

Levels of up to 80 per cent parasitism have been recorded in some refuges supporting high populations of Helicoverpa. This could devalue these crops as refuges. It should be noted that assessments of refuge productivity have always been based on numbers of live unparasitised pupae that have survived in the refuges.

The fact that natural mortality factors can be active in refuges demonstrates a possible two fold benefit from such crops. On one hand, the refuges are producing moths to assist with resistance management, while on the other they are generating large numbers of beneficial organisms that can only assist with area wide IPM efforts.

Information gathered in this ongoing research on refuges is reviewed regularly. It has assisted with identification of recommended refuges that are allowed as part of the legal requirement for growing Ingard cotton in Australia.

It allows all Ingard growers to share in the responsibility for resistance management. Growers should consult their latest Cotton Pest Management Guide available from the Cotton CRC Technology Resource Centre for up-to-date information on planting refuges.

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