Comparing invertebrate communities in Bt and conventional cotton

By Louise Lawrence, CSIRO

Bt has been used against Helicoverpa in cotton for over 30 years, first as a spray and now in transgenic Bt cottons. It is useful in Integrated Pest Management (IPM) strategies because it affects only lepidopteran (moth) pests, does not harm beneficials or the environment and doesn't poison mammals.

Bt cotton is more useful in IPM than Bt sprays

As a spray, it had a major drawback. Its efficacy was not as good as conventional insecticides and so it required careful and well-timed applications to be useful in IPM. Bt sprays break down quickly in sunlight, and coverage can be variable.

By contrast, the Bt in Bt cotton is present throughout the growing season. The new generation of two-gene Bt cottons provide consistent control of Helicoverpa which has led to further dramatic reductions in the use of chemical sprays. This has made these cottons a valuable platform for IPM as very few insecticides are applied to control Helicoverpa, allowing beneficial arthropods to contribute to control of a range of other pests.

But because of the differences between Bt sprays and Bt expressed by plants, there may have been unknown side effects of transgenic Bt cotton on insects and spiders. Obviously Bt cotton will affect populations of Helicoverpa larvae directly — that is what they are meant to do — and this will indirectly affect predators and parasites that are specialist feeders on these larvae. But it wasn't clear whether such indirect effects extend to other non-target species.

Bt cotton has little effect on non-target organisms

As part of a comprehensive environmental impact assessment of Bt cottons conducted prior to their commercial release, CSIRO scientists looked for effects on the total invertebrate community in cotton growing areas of northern NSW. Over three seasons and on three commercial cotton farms, they studied more than 100 species groups in the canopies of different types of cotton crops. At each site there were three or four treatments:

Mary Whitehouse sampling insects in the field.

- Sprayed conventional cotton;
- Unsprayed conventional cotton; and,
- Unsprayed Bt cotton (Ingard) and/or unsprayed two Bt cotton (a forerunner of Bollgard II).

Insects and spiders in the crop canopy were sampled using a suction sampler and sampling began at seedling emergence and continued until about 20 per cent of the bolls had opened. Collected samples were taken back to the laboratory where they were killed and counted under a dissecting microscope. All the experiments involved fertilised, irrigated cotton grown on beds one metre apart with agronomic practices which followed commercial "best practice".

The following questions were asked:

- Does the overall community structure differ between Bt and conventional cotton?
- Are there species groups or individual species that are more associated with Bt or conventional cotton?

There were slight but significant differences in the whole community. Statistical methods which reveal the relationships between ecological communities indicated that seasonal changes accounted for 43 per cent to 60 per cent of the community variability.

Crop type (that is, whether the crop was sprayed, Bt or conventional) accounted for nine to 17 per cent of the variability. If sprayed plots were discounted, whether the crop type was Bt or conventional accounted for only four to six per cent of the variability in the community.

As in overseas trials, no difference was found in the diversity or species richness of beneficial invertebrates in the unsprayed Bt and conventional crop types. But there were differences in diversity between unsprayed and sprayed crops, as would be expected.

Some difference between the insects and spiders found in unsprayed conventional and Bt cotton is to be expected given that the number of moth larvae has been greatly reduced in Bt cotton. It is possible that lower numbers of parasitoids

18 ▷

TABLE 1: Invertebrates whose numbers are lower in unsprayed Bt cotton compared to unsprayed conventional cotton

Common name	Function
Helicoverpa larvae	Major pest damaging all parts of the cotton plant
Jassids or leafhopper	Pest which sucks sap. Unknown whether jassids cause economic damage in cotton. Jassids can transmit diseases.
Damsel bugs	Predator in cotton.
Frit flies	None are known to be pests in cotton. Maggots feed on a range of material, including bacteria, insect eggs, plant material.
Fruit flies	Not a pest in cotton. Maggots attack fruit in other crops.
Spiders	Predators in cotton.

Only Helicoverpa is strongly affected, the others are only slightly lower (see Figure 1) in Bt cotton.

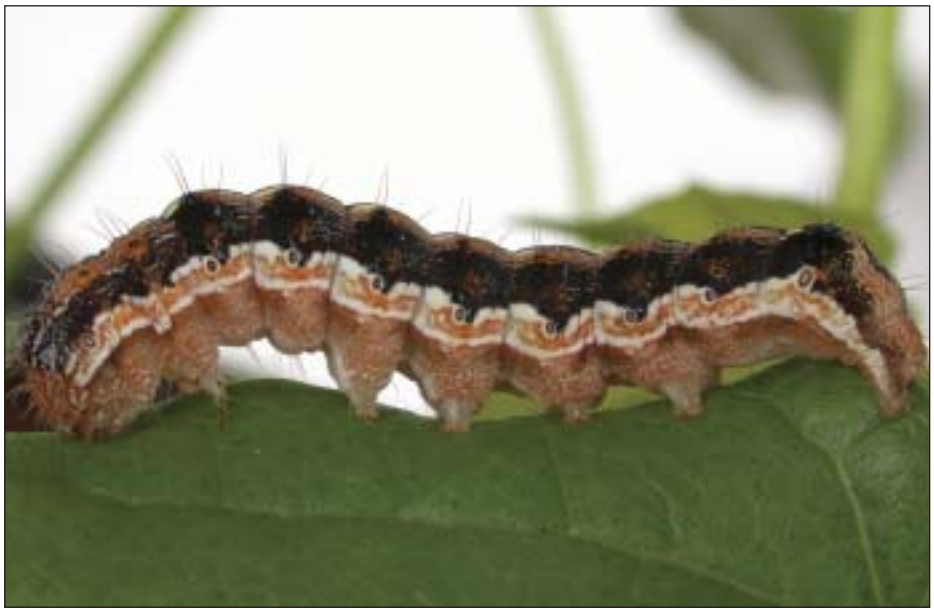
or predators which specialise on larvae could be causing this difference.

But there were no consistent differences between the number of egg and larval parasitoids of moths throughout the season, although there were slightly lower numbers of beneficial and pest bugs (Hemiptera) in Bt cottons in comparison to unsprayed conventional cotton. These bugs include damsel bugs and jassids (leafhoppers) both of which were in lower numbers in Bt cotton and may have driven this effect (Figure1).

Observations in commercially grown Bt cotton crops in Australia have also shown lower numbers of damsel bugs compared to conventional crops. The reason for this is unclear.

It may be that they are more dependent on moth larvae for food than was thought, which could partially explain their reduced abundance. Likewise the drop in larvae numbers may also account for the slight but significant drop in spider numbers in Bt crops (Figure1).

Jassid densities were slightly but significantly lower in Bt compared to conventional cotton. As jassids are sometimes considered a pest, this could be a bonus for growers.



A larva of *Helicoverpa armigera*.

The numbers of two groups of small flies — frit flies and fruit flies, were lower in Bt cotton compared to conventional cotton. Why is unclear. The Bt cottons used in this study produced Bt proteins which are specifically toxic to moths, and it is unlikely that the Bt protein in cotton had a direct effect on these flies

The role of frit flies in cotton is unclear. Larvae of this family are reported to feed on a diverse range of organisms, including bacteria, vegetative matter (both living and rotting), the eggs of other insects and spiders, beneath the skins of living frogs and as parasites of wasps and bees. One species is a pest of wheat in Europe. As frit flies do not appear to be pests or ben-

eficials in cotton, their role from an IPM perspective is probably limited to providing an alternative food source for some predators.

Implications for cotton management

The greatest influences on invertebrate communities in cotton are insecticide sprays, and the advent of Bt cotton has seen a large drop in insecticide applications (56 per cent in Ingard and 86 per cent in Bollgard II). Nevertheless, when managing Bt cotton it is important to understand how the dynamics of pest and beneficial species may be affected so that management practices can be adjusted if necessary.

The results of this research indicated only a subtle shift in the invertebrate community between Bt and conventional cotton, some of which was probably driven by the reduction in Helicoverpa and other moths. There was no indication of changes in key species which would warrant a different pest management approach.

This research highlights the value of pre-emptively looking at issues such as non-target effects for these new technologies. Such studies of non-target impacts will be important for any new transgenics. The uptake of Bt cotton has led to dramatic reductions in insecticide use. As the area of Bt-cotton increases (it is estimated to be about 80 per cent for 2005–06) the effect of reduced insecticide use and subtle non-target effects may necessitate changes to current pest management strategies. Research is under way to consider these issues.

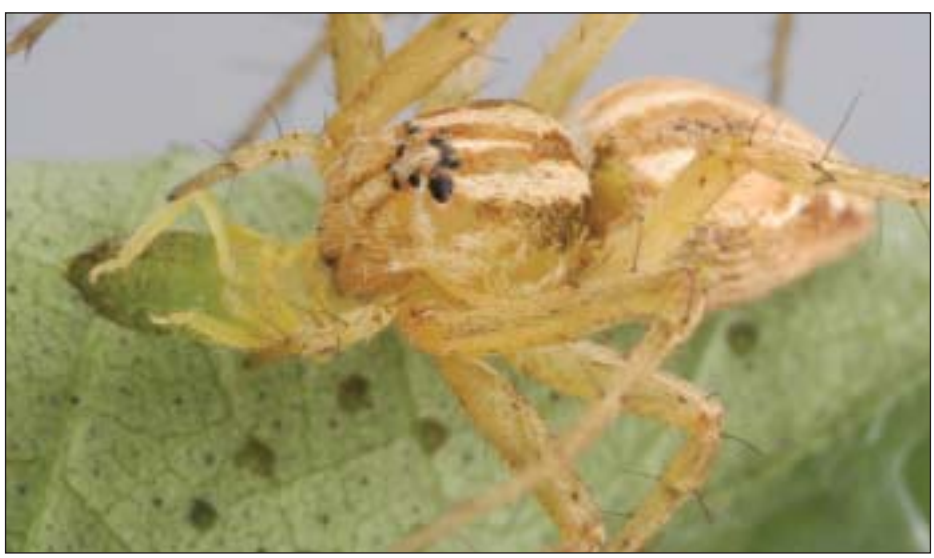
Thanks to David Blows and Cory Piper ("Doreen") and to the management of Auscott Ewenmar (Macquarie Valley) and Auscott Narrabri, in particular Stefan Hengeller, Ben Stephens, Chris Hogendyk and Matthew Seccombe who supported these trials on their farms. Deirdre Lally, Jane Caton, Allison Wales, Dee Hamilton, Kym Bush and Belinda Bennett are especially thanked for their efforts in conducting the field sampling and laboratory identifications of insects.

Contacts: Mary Whitehouse, Australian Cotton CRC and CSIRO Entomology Ph: 02 6799 1538, Fax: 02 6793 1186, email mary.whitehouse@csiro.au.

Lewis Wilson, Australian Cotton CRC and CSIRO Plant Industry, Ph: 02 6799 1550, Fax: 02 6793 1186, Email: lewis.wilson@csiro.au.

Gary Fitt, Australian Cotton CRC and CSIRO Entomology, Ph: 07 3214 2828, Fax: 07 3214 2885, Email: gary.fitt@csiro.au.

FIGURE 1: Bt cotton and invertebrate populations



The lynx spider, *Oxyopes molaris*, eating a green mirid.