

Do GM crops harm beneficials?

By Sharon Downes, CSIRO Entomology

Among the benefits of growing genetically modified (GM) crops that incorporate toxins is a reduction in insecticide use for pest control. Conventional non-selective pesticide sprays also kill many of the insects accompanying the target species. By reducing the number of sprays needed to control target pests, insect-resistant crops help to preserve these non-target arthropods — many of which are beneficial to producers.

Most insect-resistant crops are specific to a group of insects that includes the target pest but excludes natural predators and parasitoids. But these beneficial arthropods might feed on insects that take up toxin without being killed, or digestive by-products of insects such as honeydew that are contaminated with toxin. So, while insect-resistant crops may not directly kill beneficial insects, they could harm them indirectly through feeding.

This article summarises some findings from laboratory studies on this topic presented at the recent International Congress of Entomology in Brisbane.

The insect-resistance mechanisms

The studies focussed on two insect-resistance mechanisms. The first type is insecticidal proteins produced by Bt, which is a bacterium that occurs naturally in the soil. It is very selective — different strains of the bacterium specifically kill insects belonging to a certain order (butterflies/moths, beetles, flies). But no Bt toxins work well against sap sucking pests.

The second is a gene encoding a glycoprotein from snowdrop (*Galanthus nivalis agglutinin*, generally known as GNA) which has been successfully engineered into a number of crops. GNA has a much less specific mode of action compared to Bt toxins, affecting a number of plant feeders including sap sucking pests.

Again in contrast to Bt toxins, it reduces the health of target pests rather than killing them. GNA modified plants are currently undergoing extensive studies and it may be a long time before they could become available commercially.

Effects of contaminated food

When sap suckers feed on GM plants, the honeydew these insects produce can contain the insecticidal protein. To test whether this contamination is a risk for honeydew-



Insect-resistant GM crops can help to preserve non-target arthropods like this ladybeetle larva which is a major predator of aphids. But do GM crops harm these beneficial arthropods through feeding?

feeding insects, Petra Hogervorst and her colleagues from Agroscope FAL Reckenholz in Switzerland focused on a wasp parasitoid that attacks aphids (*Aphidius ervi*) that are susceptible to GNA.

The lifespan of the parasitoids was similar regardless of whether they were fed honeydew of aphids from GNA wheat plants or non-transformed plants. Further tests showed no difference in the make-up of honeydew from aphids on both plant types. So, in this case, GNA is probably not being transported in the sap.

Plant modification may interfere with the choice of host eggs by parasitoids, and these arthropods could be exposed to Bt toxins that are absorbed by eggs laid on GM plants. Barbara Manachini and Giuseppe Carlo Lozzia from the Agricultural Entomology Institute of Italy exposed two generations of adults of the parasitic wasp *Trichogramma brassicae* to corn borer (*Ostrinia nubilalis*) eggs laid on Bt (Cry1Ab) corn leaves and non-transformed leaves.

In the first generation similar proportions of eggs were successfully parasitised on both plant types. But in the second generation there was a marked decrease in emergence time of wasps that infested eggs laid by corn borers on Bt plants.

The development, growth, reproduction and lifespan of bigeyed bugs (*Geocoris punctipes*) reared on eggs of corn earworm (*Helicoverpa zea*) or beet armyworm (*Spodoptera exigua*) were not affected by whether the food was present-

ed on Bt (Cry1Ac) cotton or non-transformed cotton. John Ruberson and Jorge Torres at the University of Georgia interpret their finding as support that Bt cotton does not directly or indirectly affect these generalist plant and insect-eating bugs but also note that the outcome may be different for specialist predators.

Effects of reduced food quality

GM plants could also indirectly harm beneficial insects if the transgenes reduce the quality of the host or prey insects that are available for feeding.

Female wasps that parasitise aphids lay eggs singly in insects and the developing larvae consume the aphids from the inside. Solveig Aasen and her colleagues from the Agricultural University of Norway found that newly hatched wasp parasitoids (*Aphidius colemani*) that fed on target aphids (*Mysuz persicae*) from GNA potato plants developed to the same stage half a day later than those fed on aphids from non-transformed plants. Because no GNA was detected by analysing the aphids, this finding cannot reflect the toxin but instead may signal a poorer 'quality' aphid when reared on transgenic plants.

Because corn borers are killed by Bt, Christopher Sanders and his colleagues at Rothamsted Research and the University of Southampton in the UK studied a related pest that shows reduced growth but not certain death when exposed to Bt. The cocoon and adult weights of the larval endoparasitoid wasp *Campoletis sonorensis*

10 ▷

sis were reduced by 15 to 30 per cent when they were reared in fall armyworm (*Spodoptera frugiperda*) fed Bt corn containing Cry1Ab. The extent of this effect depended on the weight of the host larvae when the parasite eggs were laid and the wasp emerged, although the toxin may also have had at least some direct influence.

Joerg Romeis and his colleagues from Agroscope FAL Reckenholz fed larvae of the green lacewing (*Chrysoperla carnea*) with insects that either:

- Do not retain toxins from Bt (Cry1Ab) corn plants (bird cherry aphid, *Rhopalosiphum padi*);
- Which retain the toxin but are immune to its effects (glasshouse spider mite, *Tetranychus urticae*); or,
- Which retain the toxin and are sublethally affected (cotton leafworm, *Spodoptera littoralis*).

While development and survival of predator larvae was unaffected when fed with aphids or spider mites reared on Bt or non-transformed plants, lacewing larvae were negatively affected when fed exclusively with the cotton leafworms. Since aphids and spider mites are the predominant prey of the lacewings in the field and cotton worms are rarely eaten, these predators



More field research needs to be done before we know for certain whether GM crops can harm beneficial arthropods through feeding.

are unlikely to be affected by the Bt-transgenic maize.

What do these findings mean?

When no effects of the transgenic plant on the natural enemy were recorded, we can be fairly sure that GM crops will not directly or indirectly affect the insects that were studied. But, in all other cases, further information is needed to extrapolate the effects measured in the laboratory to the field.

The significance of any effect depends on how frequently the studied combination

of insects interact with each other in nature — and so the need to repeat the experiments in more natural settings. It also relies on how the effects on beneficial insects measured in the laboratory translate into their reproductive success (fitness) in a field.

It is critical to consider the combination of species selected for these laboratory studies. Clearly, more weight should be placed on findings for those that are ecologically and economically important and that involve natural enemies that are actually exposed in nature to the toxins expressed by GM plants.

Generally, a negative effect on natural enemies has been reported only when the host or prey being studied are susceptible to the deployment of toxin. There is no indication that Bt toxins expressed by transgenic crops cause direct toxic effects on biocontrol agents, but the evidence for GNA is less convincing.

These results show that field research needs to be done so we know for certain whether GM crops can harm beneficial arthropods through feeding, and how this might vary among situations. But, for now, it appears the answer may be largely 'no', at least for Bt varieties that are grown commercially.

This agrees with the results of various large-scale field studies conducted in the United States, that show no or limited impact of Bt crops on arthropod predator communities. This result is particularly clear when the Bt fields are compared with neighbouring conventional fields that are sprayed with insecticides — the arthropod diversity in the latter is obviously reduced.

Contact: Sharon Downes, CSIRO Entomology,
Ph: 02 6799 1500, Fax: 02 6793 1186,
E: sharon.downes@csiro.au

