Herbicide-resistant Sting in Honeybee's Tail

Honeybees can carry pollen over large distances, raising concerns that they may transfer herbicide resistance from genetically modified crops to closely related weed species. However, Jeanine Baker finds that overuse of existing herbicides is more likely to spread herbicide resistance to weeds.

Ever since the genetic modification of organisms has been possible there has been considerable debate about whether scientists should be using the technique to alter the characteristics of crops.

Many people believe the idea of genetically modifying plants is acceptable if there are clear benefits, while others believe that this biotechnology should not be used because it is "unnatural". However, people have been interfering with natural processes for thousands of years, and selective breeding has produced crops and animals that would probably never have evolved naturally.

Canola is an important winter crop grown in Australia. Apart from its role as a crop, canola also forms part of the rotational management systems currently used to improve wheat production. Many weeds – such as wild turnip, ryegrass and barley grass – cannot be controlled in conventional canola varieties and cause significant problems for canola growers.

Genetic modification now offers the promise of a wider range of varieties with traits that enhance resistance to disease, herbicides and adverse growing conditions. For example, genetically modified canola offers substantial benefits for farmers and consumers.

However, the possibility of unwanted gene transfer between varieties could become an issue for farmers trying to grow and sell unmodified varieties. Concerns have also been raised that fertilisation of closely related weed species with pollen containing new characteristics, such as herbicide resistance, could have a major impact on the ability to control these weeds.

Plants have reproductive systems that are more variable than those in most animals. In many plants, both sexual and asexual means of reproduction are possible. Sexual recombination is an important reproductive strategy for plants because it allows new combinations of genes that can give a plant an advantage in a changing environment.

Pollination is an important part of the sexual life cycle of flowering plants. Pollinators – typically insects, birds or bats – are first attracted to a flower and then provided an enticement to return, in the form of nectar or pollen. They may visit many flowers to collect this reward.

Although canola is mainly self-fertilised, wind and insects assist in the movement of pollen between flowers. The number of pollinators visiting a crop field and the behaviour of the insects on individual flowers will influence the level of pollen movement within and between fields.

Many farmers and beekeepers believe that honeybees help to increase the seed yield of canola by increasing the levels of cross-pollination between plants. Consequently honeybee hives are often placed near canola fields as the plants begin to flower to help the farmer and to give the honeybees a source of pollen and nectar.

Honeybees could be a significant means of moving genetic material, via pollen, around the landscape. Although honeybees have been recorded travelling 13 km from their hives, they usually forage in a 360° radius of about 2 km around the hives.

Genetically modified herbicide-resistant canola is not being commercially grown in Australia, but herbicide-resistant canola varieties have already been developed using

While bees can travel large distances, they prefer to pollinate flowers closer to their hive.

conventional breeding techniques. The possibility of canola, which is a member of the common Brassica family, cross-pollinating weed species from the same family, such as wild radish, and giving them immunity to a widely used herbicide is real, so researchers at the Cooperative Research Centre for Australian Weed Management have undertaken intensive research on working honeybees.

First, our team looked at how often honeybees moved between fields and how far they foraged for food. This was done by spraying canola fields, and the bees in them, with fluorescent paint and then going back to the fields at different times to capture the honeybees at different distances in the original and adjacent fields. The capture of any fluorescent honeybees provided information on how far the bees moved within and between fields.

The results showed that honeybees will work a canola crop very industriously, and pollen will be distributed throughout the field. Similarly, the honeybees stayed close to the hive and did not move between fields except when the hives were placed on a fence line or food resources became low.

Nectar plumes – the sweet smell of a large nectar source – attract honeybees and they keep returning to the same flower type and area as long as the nectar is plentiful. So unless the honeybees are forced to search elsewhere for food they do not carry pollen great distances. Honeybees also prefer to take the pollen back to the hive to feed their larva, so they prefer to stay close to the hive.

This means that the chance that a honeybee will carry genetically modified pollen a great distance is very low.

Even more importantly, just because a honeybee moves a great distance doesn't mean that the next flower she lands on will be fertilised by the pollen she is carrying. The flower has to be receptive and compatible to the pollen.

Therefore we have also followed individual bees from flower to flower and observed how and where they were moving. This enabled us to build a picture of the complex patterns of bee behaviour in the field.

We set up an experiment where herbicide-resistant plants were situated among herbicide-susceptible plants, and tracked honeybee movements from the time they first visited a herbicide-resistant plant in flower until the honeybee couldn't be followed any more. The flowers visited by the honeybee were bagged so they would receive no more pollen from outside.

Seed will now be collected from each flower, germinated and tested for herbicide resistance. If the seedling survives then it is a herbicide-resistant strain and the honeybee bee was involved.

Using this information we can determine how many flowers a single honeybee fertilises after visiting a specific plant. This will make it easier to predict how many flowers a honeybee, travelling a long distance from her original pollen source, is likely to fertilise. The intense interest in honeybees will answer some of the pressing questions about gene flow and help to determine the size of buffer zones required to prevent gene flow between crops.

What this research won't answer is how to prevent plants from evolving herbicide resistance naturally. Weeds are evolving resistance even more rapidly than new herbicides are being developed.

Resistance evolves when a successful herbicide is used intensively. The herbicide kills sensitive plants while allowing the rare resistant plants to survive and set seed. Eventually, if a herbicide is used persistently enough, the weed population becomes composed entirely of resistant plants.

This is how nature works, spreading successful genes that improve the chance of a plant's survival. It's just that in this instance it's working against the interests of farmers.

This should remind us that gene flow is a natural event and managing it is a balance of good land management and careful herbicide use.

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