Moths Take the Field Against Biopesticide

Just as farmers are switching to safer biopesticides, pests are already developing resistance to them

WHEN AGRICULTURAL RESEARCHERS FIRST learned about the soil bacterium *Bacillus thuringiensis* (*Bt*) in the 1950s, they thought they'd found the perfect natural ingredient for controlling insects. The bacterium produces an array of toxins that, when sprayed on crops, zero in on insect pests, killing them but leaving other bugs, animals, and humans unscathed. Suddenly there was an alternative to synthetic pesticides and all the problems they were raising in the public mind. No wonder *Bt* has become the most promising ingredient in a new generation of pest control sprays called biopesticides—indeed, they have been extolled not merely by researchers but also by environmentalists.

But reports coming from Hawaii, Florida, New York, the Philippines, Thailand, and Japan suggest the bloom is off the rose for *Bt*: One major plant pest—the diamondback moth—has evolved resistance to *Bt* toxins, and university researchers have bred several other insects in their labs that show signs of it. Worse, no quick fixes emerged from a colloquium of researchers, environmentalists, and regulators who gathered in Washington, D.C., last week* to look for strategies to nip the problem of *Bt* resistance in the bud. The fate of *Bt*, attendees concluded, will depend on voluntary efforts by farmers to use *Bt* sparingly and to adopt other pest management tools. But if voluntary efforts fail, or if alternate biopesticides prove as vulnerable as *Bt*, there's much to lose: Farmers will have to return to the use of less safe synthetic pesticides (that is, those that still work), and industry stands to lose its investment in a variety of biopesticides that make use of *Bt* toxins. Monsanto Chemical Corp., for one, has been inserting the *Bt* gene into the genome of transgenic plants, with the hope of producing supercrops with built-in resistance to insects. But now Monsanto is worried that the bollworm will be resistant to *Bt* soon after its first transgenic cotton seeds hit paydirt in the mid-1990s.

It took decades to learn how to use *Bt* in scale, but during that time, the one surety seemed to be that pests would find it tough to evolve an effective defense against *Bt*. That's because the bacterium forms spores containing several different crystallized toxins. When insects ingest those crystals, the toxins attack the cell membranes lining their guts—killing the insects. But the special beauty of *Bt* was twofold: First, only certain kinds of insects—caterpillars, beetles, and flies (including mosquitoes)—had gut chemistry that would activate these endotoxins. The result was a pesticide that was relatively harmless to many beneficial inspect species. Second, entomologists had never seen insects in the field evolve resistance against a pathogen with multiple endotoxins—until 1986.

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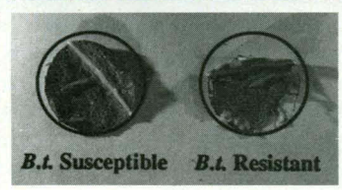

Bt strikes out. *Moths develop a taste for* Bt *in a watercress field in Hawaii* (above) *and in the lab* (left), *where larvae munch on* Bt-*treated leaf at right.*

In that year, researchers at the University of Hawaii were stunned to hear from a watercress grower on the island of Oahu that *Bt* had lost some of its ability to kill diamondback moths in his field. But a closer analysis suggested that the numbers were insignificant, says evolutionary biologist Bruce Tabashnik, a professor of entomology at the University of Hawaii.

So the farmer continued to use *Bt*, and by 1989 lab tests showed that the level of resistance had doubled. Meanwhile, the University of Hawaii team also had found resistant moths in another watercress field on Oahu and on a cabbage farm on the island of Hawaii. The common denominator in all these cases was that the growers used frequent, high doses of *Bt*—one sprayed his crop 15 times in 1989 alone.

Then came worse news. Other reports began to trickle into the literature about moths that were resistant to *Bt* in Thailand, the Philippines, Japan, Florida, and New York. At the same time, entomologists at the University of Hawaii, Cornell, North Carolina State University, and elsewhere had bred a variety of insects and exposed them to different levels of *Bt*. Although there are significant differences between insect species, they found that when insects were exposed to particularly high doses (killing 60% to 90% of the population), their offspring were more resistant to *Bt*. "When you kill 90% of the population, there's tremendous pressure to adapt and develop resistance," says Michael Caprio, now a postdoc at the University of California at Berkeley.

Armed with the latest data from the laboratory, researchers have designed strategies to prevent—or at least slow down—the onset of resistance. They are finding that the same basics of good crop management apply here: rotating crops with those that are not treated with *Bt*, and using the biopesticide sparingly. Another way to postpone resistance is to leave some plants free of *Bt* so they can serve as refuges for susceptible insects. These bugs will breed with resistant ones, and since the resistance trait is believed to be recessive, it will take longer to show up in the population.

Researchers at last week's meeting also urged Monsanto to sell its transgenic seeds in mixtures with normal cotton seeds when it introduces them in the mid-1990s, so farmers won't plant entire fields of plants with *Bt* toxins—and thereby up the ante for bollworms to become resistant.

But for these plans to work, they have to be put into action, and the experts meeting in Washington last week learned that they can't expect much help from the government on that score. Ann Lindsay, director of the Environmental Protection Agency's registration division in the office of pesticide programs, disappointed workshop scientists by telling them that the agency had no plans to regulate the use of new biopesticides. This means that the only hope for convincing farmers to use *Bt* sparingly is to persuade them that it's in their interest to forsake some short-term income (by allowing insects to damage some of their crops) to make sure they have *Bt* as long as possible. But whether struggling farmers will be any more farsighted than the average U.S. corporate executive remains to be seen. ■ ANN GIBBONS

*The "Bt Resistance Workshop," sponsored by the National Audubon Society on 21 October.