Testing Two Corn Rootworm Controls

Corn rootworms are the number-one pest of corn, costing farmers hundreds of millions of dollars a year in pesticides and lost crop yields. By being the first pest ever to evolve a way of foiling crop rotations, the corn rootworm may have given genetically modified (GM) crops their biggest boost ever. Now, Agricultural Research Service researchers are partnering with industry to test GM corn's ability to curb this adaptable pest.

Crop rotations are the standard nonchemical way farmers—both conventional and organic—keep pest levels down. The idea is to plant a crop, like corn, in a field or garden one year and then rotate to a different crop, such as soybeans, the next year. Any corn rootworms that move in to breed and feed on the corn will survive, but their offspring will starve to death the next year, because they'll hatch in a field of soybeans.

But a few years ago, something very new and strange happened. The western corn rootworms themselves began rotating fields, to make sure future generations were always born in a cornfield, not a soybean field. Adult beetles began flying out of cornfields just long enough to lay their eggs in soybean fields that would become cornfields the next spring, when their hungry larval offspring would hatch in the soil. Northern corn rootworms took another tack: They laid eggs that took 2 years to hatch, so they'd hatch only when the fields were rotated back from soybeans to corn.

SCOTT BAUER (K10173-2)

Western corn rootworm larvae (about one-quarter inch long).

Corn rootworm is the first pest to evolve a way to defeat crop rotations.

SCOTT BAUER (K10170-1)

Entomologist Wade French examines corn roots from plots that have been artificially infested with western corn rootworm. The nontransgenic root on the right shows considerable damage from the pests, but the transgenic root on the left has very little damage.

Changing the Plant

Now, scientists are looking to control rootworm by using a GM corn that is moving through regulatory channels for possible use in time for spring 2003 planting. YieldGard Rootworm corn has been genetically modified to produce a protein toxin derived from *Bacillus thuringiensis (Bt)*, a common and naturally occurring soil bacterium. This bacterial insecticide kills rootworms when they feed on corn plants.

One concept that will be tested on a large scale is use of a mix of conventional and GM corn seed. The seed-mix concept is based on cooperative research by ARS and Monsanto Company, St. Louis, Missouri—the developer of the new corn variety. In the field, plants that grow from the conventional corn seeds in the mix serve as a refuge for some of the beetles. This ensures there will be rootworm beetles not exposed to *Bt* available to mate with any *Bt*-resistant survivors. The offspring will likely not be resistant, which will slow the evolution of beetles resistant to *Bt*.

Under a 5-year cooperative research and development agreement that is up for renewal in 2003, the researchers tested various seed mixtures. They found that those with 10 to 20 percent conventional corn seed provided the same rootworm control, on average, as 100-percent GM seed. With rootworm control superior to that offered by a conventional insecticide, the seed-mix approach may provide an effective strategy to slow down the evolution of resistance to *Bt*. While further research is required for seed-mix strategies, the U.S. Environmental Protection Agency is reviewing Monsanto's application to sell YieldGard Rootworm corn for 3 years only at first. This will allow Monsanto time to conduct additional studies with ARS and university scientists.

The *Bt* corn offers a way to reduce use of conventional insecticides, says Wade French, an ARS entomologist at Brookings, South Dakota. French and colleagues are researching the seed mix in cooperation with Monsanto and conducting other research on rootworms. The wormlike larvae cause most of the damage to corn by devouring plant roots—their dietary mainstay. French and colleagues evaluate feasibility of seed mixes by rating root damage and plant lodging (falling) and monitoring numbers of adult corn rootworm beetles caught with emergence cages.

So far, all seed mixtures tested have worked as well as conventional insecticide, and most of them did much better. But the mixtures with no more than 10 to 20 percent conventional corn seeds worked best. "This makes us think that a seed mix will control rootworms while also slowing down the development of resistance," French says.

SCOTT BAUER (K10169-1)

Pitfall traps with timed interval units are used to study daily activity cycles of beneficial ground beetles in corn and soybean cropping systems. Here (left to right), biological aides Ryan Hericks and Matt Jones, entomologist Mike Ellsbury, and graduate student Chris Noble prepare to collect beetles from a trap.

Protecting Helpful Predators

But will the *Bt* corn also kill beneficial bugs such as ground beetles, some of which are fierce predators of rootworms? The family Carabidae includes more than 20,000 species of ground beetles, making them the second largest group of beetles in the world. Ground beetles are ubiquitous and common in both rural and urban areas, where the larger beetles are often mistaken for cockroaches.

In a study designed to investigate the potential impact of *Bt* corn on ground beetle species composition, French's colleague Mike Ellsbury, also an ARS entomologist, set up 105 pitfall traps, each one a single plastic cup, or pit, for beetles to fall into. He placed the traps in experimental plots planted with a mix of YieldGard Rootworm corn and conventional corn. The plots were scattered over 40 acres of soybean fields

on private farms. By keeping track of the numbers and species of beetles in the test plots, the researchers will have an indication of whether the the corn harms the insects.

Ellsbury collected 20,000 ground beetles this past growing season—as many as 5,000 in 48-hours—representing 60 different species.

All seed mixtures tested have worked as well as conventional insecticide, and most of them did much better.

French also placed pitfall traps to monitor ground beetles on private farms, where some farmers are growing another type of *Bt* corn to control corn borer pests. These farms are part of a national areawide pest-management project designed to reduce the corn rootworm population across the Corn Belt with a variety of techniques, including nonchemical means.

Ellsbury is also experimenting with three nighttime traps created by modifying a commercial mosquito trap. He and colleagues converted the trap from one suspended on a pole in the air to one buried just beneath the surface of the soil. The trap nabs adult beetles as they race across the surface of cornfields at night, devouring rootworms—and just about everything else they encounter. The researchers attached the rotating trap mechanism to a circular panel of recycled plastic so they could cover it with soil and crop residue, completely disguising it, with only a single pitfall opening exposed at the ground surface.

The trap is like a clock, set to rotate every 3 hours, so that beetles fall into one of eight different collection bottles. Researchers can then see not only how many and what kind of beetles are present, but also—within a 3-hour span—when they were caught. This tells researchers exactly when different species of beetles are active, which offers clues as to who or what they're eating.

With the decreasing effectiveness of the crop-rotation strategy in corn farmers' arsenals, growers must increasingly turn to conventional pesticides or beneficial insects to combat rootworms—or to a new weapon: corn plants genetically modified to produce a pesticide that affects only corn rootworms.—By **Don Comis,** ARS.

This research is part of Crop Protection and Quarantine, an ARS National Program (#304) described on the World Wide Web at http://www.nps.ars.usda.gov.

Wade French is with the USDA-ARS Crop and Entomology Research Laboratory, 2923 Medary Ave., Brookings, SD 57006; phone (605) 693-5219, fax (605) 693-5240, e-mail wfrench@ngirl.ars.usda.gov. ★

SCOTT BAUER (K10172-1)

Biological aides Dale Beckendorf (right) and Heather Schilder (center) help technician Eric Bekendorf (left) prepare cages used to catch corn rootworm beetles for study.

SCOTT BAUER (K10170-9)

Biological technician Dave Beck and biological aide Sarita DeBoer examine species of ground beetles captured in fields rotated with corn and soybeans.