Entomologists devise new test for insecticide resistance

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A pair of sweet potato whiteflies on a plant leaf. Whiteflies are a common crop pest in Arizona and elsewhere, and damage the state's cotton industry by weakening plants and fouling cotton gins. Credit: Stephen Ausmus

(PhysOrg.com) -- A 10-year study has led to a model that assesses the effectiveness of insect refuges in slowing evolution of resistance.

A team of entomologists led by University of Arizona Professor Yves Carrière have devised and implemented a new test to help farmers in their never-ending war against insect pests. Based on nearly a decade of dogged research, they've provided the first direct evidence confirming the effectiveness of the so-called refuge strategy for delaying pest resistance to insecticides.

Farmers use refuges to delay the evolution of resistance by insects to insecticides that are sprayed or made internally by genetically engineered plants, called Bt crops. Scientists have long known that while insecticides may kill most of the pests initially, they will adapt quickly if the rare survivors have genes that render them resistant. This, said Carrière, is "a prime example of Darwinian evolution in which the fittest insects survive and pass the genes for resistance to their offspring."

Refuges are safe havens where insects are not exposed to insecticides. Non-resistant insects can survive in refuges and live to mate with the few resistant insects that survive exposure to insecticides. In principle, refuges will help to delay evolution of resistance. Computer models, small-scale laboratory experiments, and retrospective analyses suggest that refuges work, but a direct, large-scale test of refuges has been elusive – until now.

Yves Carrière, a professor of entomology, and his colleagues at the UA and several other institutions in the U.S. and Canada tested the effectiveness of refuges in Arizona against whiteflies using 8 years of data from laboratory bioassays, as well as GIS data from crop and pesticide distribution maps. Their work is published in the Jan. 6 issue of the *Proceedings of the National Academy of Sciences* (Large-scale, spatially-explicit test of the refuge strategy for delaying insecticide resistance).

Since 1996, the Environmental Protection Agency has mandated that farmers in the U.S. who plant Bt crops, which make insecticidal proteins from the bacterium Bacillus thuringiensis, also plant refuges.

EPA regulations stipulate the proportional area of refuges to be planted in a region and the maximum distance between refuges and Bt crop fields. However, until now precise methods to identify habitats that are efficient refuges and the maximum distance at which such refuges can delay the evolution of resistance had been lacking.

Carrière and the others tested the refuge strategy by combing through eight years of data on the distribution and abundance of crops, application of the pesticide pyriproxyfen, and whitefly resistance to pyriproxyfen.

Pyriproxyfen is an insect growth regulator that targets sweetpotato whiteflies, a key pest in Arizona. It is applied once in cotton during the growing season, which limits the selective pressure for resistance evolution. It also is a specific insecticide that contributes in preserving natural enemies of cotton pests.

Whiteflies feed on the sap of the cotton plant, inhibiting a plant's growth and productivity, and excrete a sticky substance onto opened bolls that bear the fiber, which often reduces the value of the crop.

The test area was a swath of agricultural land in central Arizona, home to three main whitefly crops.

"It is a lot less complicated than, say, Yuma, where they grow carrots, lettuce, broccoli, cauliflower and other things. Central Arizona has only cotton, alfalfa and melons, but it has treated and untreated (no pyriproxyfen) cotton," Carrière said.

"The method we developed is data intensive because you have to monitor resistance across the landscape in different fields," he said. "And then you have to relate the spatial variation in resistance to the abundance and distribution of potential refuges and treated fields. In some fields you have high resistance; some fields you have less. And the hypothesis is that you have less resistance in some fields because you have more refuges near these fields."

The group developed spatially-explicit, statistical models based on the first four years of data that included aerial remote sensing maps and documented pesticide applications in the study area. The models identified the crops affecting the spatial variation in resistance and the maximum distance at which these crops affected resistance. They then used a separate data set from the next four years to predict resistance at the landscape level with these models. The successful prediction of resistance confirmed that refuges of cotton delayed the evolution of resistance and fields treated with pyriproxyfen accelerated the evolution of resistance.

"We had the resistance data from 84 cotton fields. What we didn't have was information on the crops surrounding these fields. We had to use remote sensing, digging back through satellite images for the last eight years, and then analyzed the images to map the crops surrounding each cotton field."

Carrière said that the method and framework developed by their research could help refine the refuge strategy for many key pests. Carrière points out that "This is important because some pests targeted by a Bt crop or insecticides are generalist feeders. They can come from many types of crops or uncultivated habitats. A pest targeted by Bt corn, for example, could come from soybeans or tomatoes or sorghum. So, then how do you know which of these habitats are efficient refuges, and how do you know the distance at which these refuges will produce enough susceptible insects to delay the evolution of resistance?"

Provided by University of Arizona