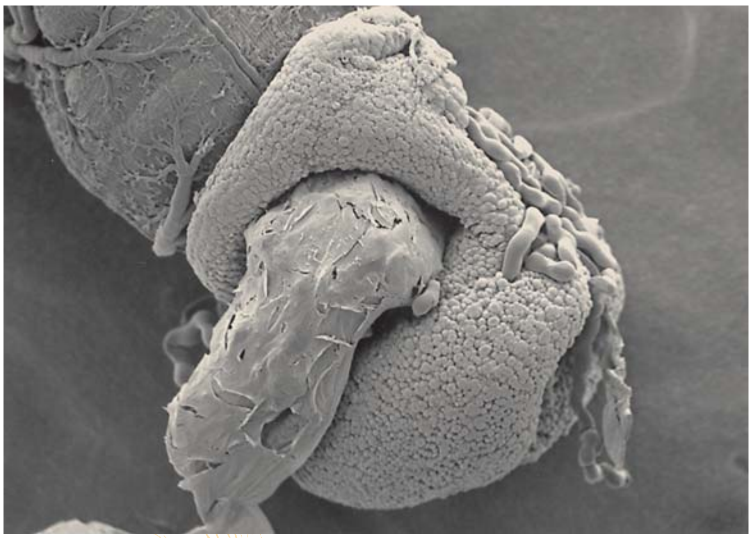
Corn Protein Puts FALL ARMYWORM on Starvation Diet

Courtesy of Tibor Pechan



Marco Nicovich

This electron micrograph (50x magnification) shows a caterpillar gut with the peritrophic matrix containing a food bolus (above left). An adult fall armyworm is shown in the photograph at right.

By Charmain Tan Courcelle

A protein made in certain strains of corn reduces weight gain by 50 percent or more. But this corn product is not the latest in miracle diet drugs for the weight-conscious consumer; instead, it's a promising new control agent for fall armyworm and other caterpillar crop pests.

MAFES biochemist Dawn Luthe, postdoctoral research assistant Tibor Pechan and Agricultural Research Service (ARS) corn breeder and geneticist Paul Williams were part of a team that first made the link between reduced larval growth and a 33-kDa cysteine proteinase produced in the leafy tissue of developing whorls from fall armyworm-resistant corn plants. The researchers recently completed a collaboration with ARS entomologist Allen Cohen that has revealed how the protein works to stunt fall armyworm growth.

The 33-kDa cysteine proteinase appears to be a novel type of plant insect-defense system, Luthe said. Unlike other plant proteins in its class, the 33-kDa cysteine proteinase acts by directly damaging a critical insect gut matrix.

"The 33-kDa cysteine proteinase causes the peritrophic matrix, which plays a role in insect digestion and nutrient absorption, to break down," Luthe said. "Damage to the peritrophic matrix throws off the balance of nutrient absorption and recycling and is harmful to insects.

"The ability of this protein to cause peritrophic matrix damage represents a different form of insect resistance in plants that has not been identified before. It could add to our ability to develop crops that can defend themselves against insect attack."

In earlier work, Luthe and her colleagues found that the 33-kDa cysteine proteinase is mobilized within an hour of larval feeding from internal stores in resistant corn. It then accumulates at the wound site for up to seven days. The group also observed that fall armyworm larvae developed more slowly when they were fed tissue from resistant corn lines compared with a control diet or a diet of susceptible material.

"The physiological indices we used suggested that insects fed a diet of resistant whorl tissue are unable to use the nutrients found in this plant material to grow," Luthe said.

Based on this first clue of nutritional impairment, the researchers decided a possible target for the 33-kDa cysteine proteinase was the caterpillar peritrophic matrix.

The peritrophic matrix forms a "sock" around the ingested food bolus and provides the proper environment for digestion and nutrient absorption within the insect midgut. It functions as a filter that allows digestive enzymes to enter into the midgut and nutrients from digested food to exit out into the circulation. The peritrophic matrix also forms a physical barrier that protects the midgut cells from invading microbes and damage caused by chemical toxins.

The research team evaluated the structure of the peritrophic matrix from caterpillars fed resistant or susceptible corn tissue to determine the effect of the 33-kDa cysteine proteinase on this digestive lining.

"We found holes, tears and gaps in the peritrophic matrix of caterpillars that were fed on resistant plants, but no matrix damage in caterpillars fed on susceptible plants," Luthe said.

Because the peritrophic matrix also has a protective function, disrupting this lining could open the insect up to attacks from pathogens, such as bacteria and viruses, that would otherwise be filtered out by an intact matrix. Holes in this lining could also allow chemical toxins to pass through.

So, the 33-kDa cysteine proteinase may be acting by both disrupting nutrient absorption and increasing the insect's vulnerability to pathogens and toxins, Luthe said.

The researchers confirmed the 33-kDa cysteine proteinase, and not some other factor in resistant corn tissue, was responsible for this effect by moving the gene for this protein into susceptible plant material (Black Mexican Sweetcorn callus).

"Only the caterpillars fed on Black Mexican Sweetcorn callus transformed with the protein had damage to their peritrophic matrix and showed reduced growth," Luthe said.

The team's success with transferring the protective effect of the 33-kDa cysteine proteinase into another plant host suggests that the protein may eventually be used to provide enhanced insect resistance in other crops. Luthe said understanding more about how resistant corn plants regulate the 33-kDa cysteine proteinase will help make this a reality.

"We hope one day to be able to protect plants against insects. The 33-kDa cysteine proteinase may provide us one more way to do so," Luthe said.

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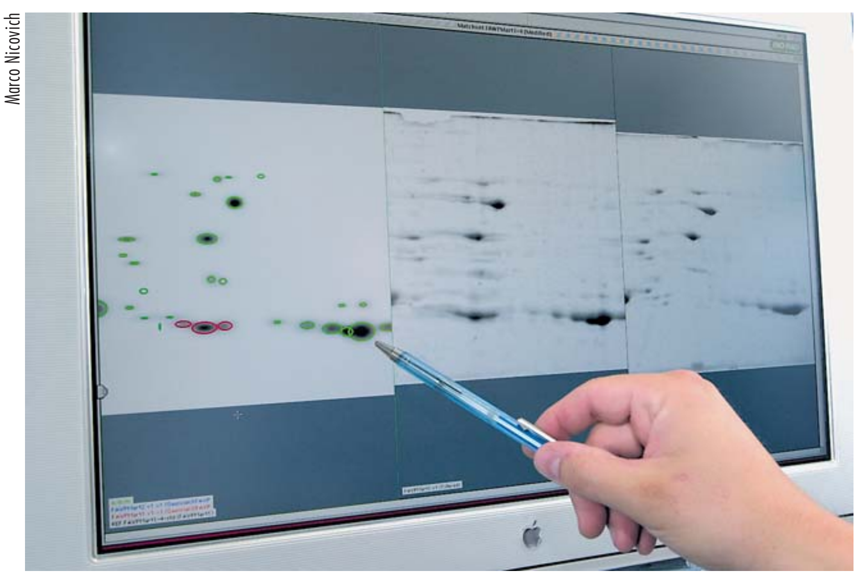

Postdoctoral research assistant Tibor Pechan examines an electrophoretic analysis of larvae peritrophic matrix proteins. Spots on the screen represent individual proteins that are structural and functional components of the matrix.