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Pests worm their way into genetically modified maize

Broadening of rootworm resistance to toxins highlights the importance of crop rotation.

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Defending fields from the rapid adaptation of western corn rootworm to transgenic toxins may require weapons beyond those of biotechnology.

Even with biotech crops, farmers still need to make use of age-old practices such as crop rotation to fight insect pests. That's the lesson to be drawn from the latest discovery of resistance to the pest-fighting toxins added to maize — also known as corn.

According to a team led by Aaron Gassmann, an entomologist at Iowa State University in Ames, in some Iowa fields a type of beetle called the western corn rootworm (*Diabrotica virgifera virgifera* LeConte) has developed resistance to two of the three types of *Bacillus thurinigiensis* (Bt) toxin produced by genetically modified maize. Resistance to one type of Bt toxin has cropped up in the worms in recent years, but now there is a twist — the researchers have found that resistance to that type of Bt toxin also confers protection against another, more recently introduced type. Their work appears in this week's *Proceedings of the National Academy of Sciences*[1].

"That's two of the three toxins on the market now," says Gassmann. "It's a substantial part of the available technology."

Genetically modified (GM) maize producing the Bt toxin Cry3Bb1, which provided protection against pests such as rootworm, was first approved for use in the United States in 2003. By 2009, farmers had started to see rootworm damage in their GM crops. In 2011, that damage had spread to GM maize containing a second toxin, mCry3A. In lab tests, Gassmann showed that this was a case of cross-resistance — worms that had become resistant to Cry3Bb1 were also resistant to mCry3A, possibly because the toxins share structural similarities and some binding sites in the insect's gut.

Part of the problem is that rootworms are tough, and the Bt maize does not produce enough toxin to fully control them. The Bt toxins used against pests such as the European corn borer (*Ostrinia nubilalis*) kill more than 99.99% of their targets, whereas more than 2% of rootworms can survive Bt maize. Resistance in the worms can evolve rapidly in fields where the same kind of maize is grown every year — in Iowa it showed up after an average of 3.6 years.

Nicholas Storer, a global science-policy leader for biotechnology at Dow AgroSciences in Washington DC, says that the study illustrates that if GM crops are not used as part of an integrated pest-management policy, resistance can develop quickly in an

individual field. Agricultural biotechnology companies such Dow are now 'pyramiding' their seeds so that they produce two different Bt toxins to attack the rootworm. For example, Dow has teamed up with Monsanto of St Louis, Missouri, to sell seeds that combine Cry3Bb1 with Cry34/35Ab1, a toxin that has so far not seen any resistance develop.

Gassmann says that the pyramiding of toxins is an important way to delay the development of resistance, but that the combination is less effective once resistance arises to one of the toxins. So farmers should not rely exclusively on technology to fight pests, and should instead periodically change the crop grown on a field to help disrupt the pest's life cycle. "The rootworm can't survive if the corn's not there," Gassmann says.

Storer agrees that even the best technologies will always need to be combined with the old methods. "Crop rotation was the primary tool to combat rootworm before Bt came along," he says. "We need to keep it up."

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References

1. Gassmann, A. J. *et al*. *Proc. Natl Acad. Sci. USA* http://www.pnas.org/cgi/doi/10.1073/pnas.1317179111 (2014).