Genetically modified corn affects its symbiotic relationship with non-target soil organisms

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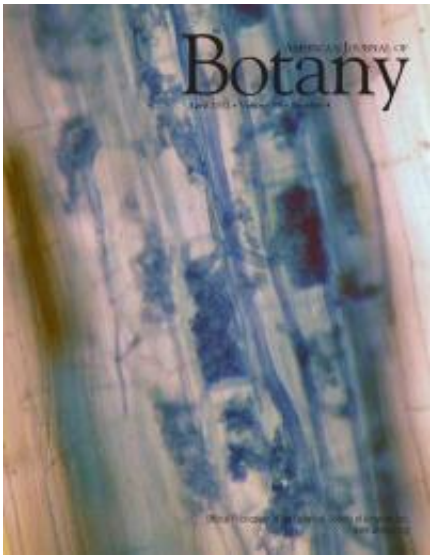

Arbuscular mycorrhizal fungi (AMF) colonizing corn (*Zea mays*) roots as viewed with a compound light microscope (400x). Roots were cleared with 10 percent KOH and stained with 0.05 percent trypan blue in lactoglycerol to visualize fungal structures. Arbuscules, which are thought to be the site of nutrient exchange between the fungus and plant host, can be seen as branching, tree-like structures within plant cells. Fungal hyphae are the thick, thread-like structures that connect to the arbuscules and extend into soil, increasing the surface area of roots, and often improving plant nutrient and water uptake. The article in the *American Journal of Botany* reports the results of a greenhouse study to evaluate AMF colonization in nine genetically modified *Bacillus thuringiensis (Bt)* maize lines differing in number and type of engineered traits, and in five corresponding near-isogenic parental base-hybrids. Insect-resistant maize is genetically modified to express insecticidal toxins derived from the spore-forming soil

bacterium, *B. thuringiensis*, to protect plants against damage from agricultural pests such as the corn rootworm and the European corn borer. Although *Bt* maize is widely cultivated, few studies have examined the interaction of different lines of *Bt* maize with symbiotic arbuscular mycorrhizal fungi in the soil. The authors examined differential levels of AMF colonization in multiple lines of *Bt* and non-*Bt* maize grown under the same experimental conditions. Transgenic *Bt* maize plants had lower levels of AMF colonization in their roots than did the non-*Bt* parental base-hybrids. This work contributes to the growing body of knowledge on the unanticipated effects of *Bt* crop cultivation on non-target soil organisms. Credit: Tanya E. Cheeke, Portland State University

An increasing number of crops commercially grown today are genetically modified (GM) to resist insect pests and/or tolerate herbicides. Although *Bt* corn is one of the most commonly grown GM crops in the United States, little is known about its effects on the long-term health of soils. Although there are many benefits to using biotechnology in agriculture, such as potentially reducing insecticide use, there may be unintended side effects as well—does GM corn impact non-target soil organisms, such as arbuscular mycorrhizal fungi, or affect plants subsequently grown in the same field?

Bt corn is genetically engineered to express insecticidal toxins derived from a soil bacterium, *Bacillus thuringiensis*, to protect it against common agricultural pests such as the corn root worm and European corn borer. Tanya Cheeke and her colleagues (at Portland State University, Oregon) were interested in determining whether the cultivation of Bt corn has a negative effect on arbuscular mycorrhizal fungal colonization of *Bt* corn or of crops subsequently planted in the same soil. They published their findings in a recent issue of the *American Journal of Botany*.

Arbuscular mycorrhizal fungi (AMF) are ubiquitous microscopic soil

fungi that form symbiotic relationships with the roots of most plants. Plants supply the fungi with carbon, and the fungi increase the host plant's ability to uptake nutrients and water from the surrounding soil.

"Because these fungi rely on a plant host for nutrition and reproduction, they may be sensitive to genetic changes within a plant, such as insect-resistant *Bt* corn," stated Cheeke.

By experimentally planting seeds from several different lines of both *Bt* corn and non-*Bt* corn, and using local agricultural soil containing native mycorrhizal fungi, the authors were able to simulate what might happen naturally in an agricultural system.

"What makes our study unique is that we evaluated AMF colonization in 14 different lines of *Bt* and non-*Bt* corn under consistent experimental conditions in a greenhouse using locally collected agricultural field soil as the AMF inoculum," said Cheeke.

"The use of whole soil in this study allowed each *Bt* and non-*Bt* corn line to interact with a community of soil organisms, making this study more ecologically relevant than other greenhouse studies that use a single species of AMF," she adds.

Interestingly, the authors found that colonization of plant roots by symbiotic soil fungi was lower in the genetically modified *Bt* corn than in the control lines. However, there was no difference in root biomass or shoot biomass between the two types of corn at the time of harvest.

Cheeke and co-authors also determined that the *Bt*-protein itself is not directly toxic to the fungi since AMF colonization of vegetable soybeans did not differ for those grown in soil previously containing *Bt* vs. non-*Bt* corn.

Together these findings contribute to the growing body of knowledge examining the unanticipated effects of *Bt* crop cultivation on non-target soil organisms. Examining non-target effects of genetically engineered crops on symbiotic soil organisms becomes even more important as acreage devoted to the cultivation of *Bt* crops continues to increase globally.

"In 2011, 88% of the corn cultivated in the United States was genetically modified to express insect resistance, herbicide tolerance, or some combination of stacked traits," Cheeke commented. "Globally, genetically modified corn is cultivated in at least 16 different countries."

Cheeke notes that the next step is to understand the ecological significance of this study. "In greenhouse studies *Bt* corn had lower levels AMF colonization, so now it is important to see if this pattern is also observed under field conditions." She plans to use field experiments to test if planting a *Bt* crop for multiple years has an effect on the abundance or diversity of AMF in the soil ecosystem.

More information: Tanya E. Cheeke, Todd N. Rosenstiel, and Mitchell B. Cruzan. 2012. Evidence of reduced arbuscular mycorrhizal fungal colonization in multiple lines of Bt maize. American Journal of Botany 99(4): 700-707. DOI: 10.3732/ajb.1100529

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