# Entomologists update definitions to tackle resistance to biotech crops and pesticides

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Resistance to pesticides has now been recorded in nearly a thousand pest species, including more than 500 insects, 218 weeds, and 190 fungi that attack plants. The recorded cases of resistance in insects, mites and other arthropods, which include resistance to multiple pesticides per species, more than doubled from 5,141 in 1990 to 11,254 in 2013.

A first step in tackling this growing global problem is establishing a common vocabulary, because the current jumble of terms fosters confusion among scientists in academia, industry and government. To address this issue, five entomologists from the University of Arizona and Michigan State University updated definitions for 50 key terms related to resistance in a new article in the *Journal of Economic Entomology*.

"The lack of a modern glossary for resistance was recently brought to our attention by an initiative of the U.S. Environmental Protection Agency (EPA) seeking input on definitions of terms about resistance," said Dr. Mark Whalon, one of the co-authors from Michigan State University, who directs the online Arthropod Pesticide Resistance Database and who also serves as the Entomological Society of America's Liaison to the EPA Office of Pesticide Programs. "We provide a list of 50 key resistance terms and definitions aimed at facilitating understanding and management of resistance."

The authors favor definitions that promote proactive detection and management of resistance, such as resistance defined as "a genetically based decrease in susceptibility to a pesticide." They contrast this with

an alternative definition used by some industry scientists that requires "repeated failure of a product to achieve the expected level of control," which generally occurs only after it's too late to respond most effectively.

The stakes are especially high for defining and managing insect resistance to corn and cotton plants genetically engineered to produce proteins from the bacterium *Bacillus thuringiensis* (Bt). These proteins kill some key pests, but are not toxic to people, wildlife, or even most insects. Organic growers have used Bt toxins in sprays for decades, and conventional farmers have widely adopted transgenic Bt crops since 1996. In 2013, Bt corn and Bt cotton were planted on 187 million acres worldwide and accounted for 75% of all cotton and 76% of all corn grown in the U.S.

Recognizing that resistance is not "all or none" and that intermediate levels of resistance can have a continuum of effects on pest control, the authors describe five categories of field-evolved resistance and use them to classify 13 cases of resistance to five Bt toxins in transgenic corn and cotton based on monitoring data from five continents for nine major pest species.

Emerging resistance of the western corn rootworm to Bt corn exemplifies the urgent need for well-defined resistance terms. The cost of this insidious beetle to U.S. corn growers has been estimated at one billion dollars annually. In 2003, to reduce costs and cut back on soil insecticides, U.S. farmers began planting Bt corn that kills rootworms.

"The first evidence of rootworm resistance to Bt corn was discovered in Iowa in 2009," said Dr. Bruce Tabashnik, the study's lead author and head of the entomology department at the University of Arizona. "Nearly five years later, the resistance has spread but decisive regulatory action by the EPA is still stalled, in part because an effective definition

of resistance is lacking in this case."

Although some scientists have expressed concern that reports of pest resistance to Bt crops provide 'ammunition' to anti-biotech activists, Tabashnik said "Pests are remarkably adaptable. They usually evolve resistance to any tactic that's used repeatedly to control them, so this problem is not limited to transgenic crops." Noting that insects have been evolving resistance to natural plant defenses for millions of years and that this year marks the 100th anniversary of the first reported case of insecticide resistance, he concludes, "Finding ways to delay resistance is a never-ending challenge with any pest management approach."

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