Biotech In focus

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GM Crops, Agriculture, and the Environment: The National Academies Weigh In

Genetically modified (GM) crops account for about 90 percent of U.S. acreage in soybean, corn, cotton, and canola. But this popularity with farmers hasn't translated into public acceptance: a 2015 survey by the Pew Research Center found that almost 60 percent of respondents believe GM foods are generally unsafe to eat. In contrast, 89% of scientist believe GM foods are safe.

In 2014, the National Academies of Sciences, Engineering, and Medicine established a committee to consider how GM crops differ from conventional (non-GM) crops. Experts from diverse fields reviewed more than 1,000 studies, observed 80 presentations, and received over 700 comments. The resulting report was released in May 2016 and is available for free download (nas-sites.org/ge-crops).

Most commercial GM crops have been engineered to tolerate herbicides, resist insect pests, or both. The committee therefore focused on these two traits. Here, we discuss findings on how GM crops have affected agricultural output and the environment. Next month's bulletin will discuss the committee's conclusions regarding the social, economic, and human health effects of GM crops.

Insect-resistant GM crops contain genes from bacteria that allow the plant to make insecticidal Bt proteins. Bt crops were compared to conventional crops of the same species to see how the genetically engineered trait affects crop yields, insecticide use, insect pest populations, and the evolution of resistance to Bt proteins. Bt sprays of proteins and bacteria are among the naturally occurring pesticides that certified organic farmers and conventional farmers can use.

Bacterial genes also enable herbicide-tolerant GM crops to make enzymes that break down one or more herbicides, most commonly glyphosate (Roundup). As the GM crop grows, the farmer controls weeds by spraying the tolerated herbicide on the entire field. Herbicide-tolerant crops and their conventional counterparts were evaluated to compare crop yields, herbicide use, the distribution of weed species, and the evolution of herbicide resistance in targeted weed species.

Crop yield measures the weight of crop produced per acre of land. Potential yield is the theoretical maximum that could be achieved if plant productivity was limited only by light, carbon dioxide, temperature, and the plant's ability to grow. Actual yield is always smaller that potential yield, because even when soil water and nutrient levels are ideal, real-world yields are limited by pests, weeds, diseases, and toxins.

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Bt Conclusions

The committee concluded that the use of Bt crops significantly reduces crop losses when Bt-targeted insect pests are common and synthetic chemicals don't control them. In other words, the gap between potential yield and actual yield is smaller for Bt crops than for conventional crops when certain insects are abundant and hard to control.

Less chemical insecticide is applied to Bt varieties than to conventional crops. Where Bt crops are widely used, populations of Bt-targeted pests have declined, so that less insecticide is used on non-GM crops as well. In some instances, insect pests that aren't sensitive to Bt have become more common, but the report found that this rarely causes pest control issues. Insect populations in Bt crop fields tend to be more diverse than in fields of conventional crops treated with synthetic insecticides. In locations where non-Bt refuges have been planted and Bt crops contain adequate Bt protein, resistance to Bt has been slow to develop. However, when these practices have not been followed, the targeted pests have evolved Bt resistance. Insect resistance to Bt sprays was reported as far back as the 1980s before GM crops. Farmers that use Bt are required by the EPA to take steps to help prevent further resistance by other insects as Bt rapidly breakdown in the field and the field requires frequent respraying.

Weed Control

Herbicide-tolerant crops were found to have increased yields when the herbicides they tolerate improve weed control. The amount of herbicide applied has not decreased, but has shifted to favor herbicides for which tolerance can be engineered. Heavy reliance on glyphosate tolerance has favored weed species that are naturally less susceptible to glyphosate, but the committee did not find that these population shifts significantly harm farmers.

Delaying Resistance

More problematically, weed species that were once controlled by glyphosate have evolved resistance. Repeated use of glyphosate has selected for resistance by killing vulnerable plants while leaving once-rare resistant plants alive to breed. Integrated pest management techniques may delay the further evolution of weed resistance, particularly in fields that have not been treated continuously with glyphosate.

Further Study

Other report topics include gene flow from GM crops to wild species and possible effects of GM crops on non-target insects, such as bees or monarch butterflies. The committee did not find cause-and-effect relationships between GE crops and environmental problems, but recommended further study to resolve questions for which current evidence is inconclusive.

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