Cooperative Extension Service
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College of Tropical Agriculture and Human Resources
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Biotech In focus

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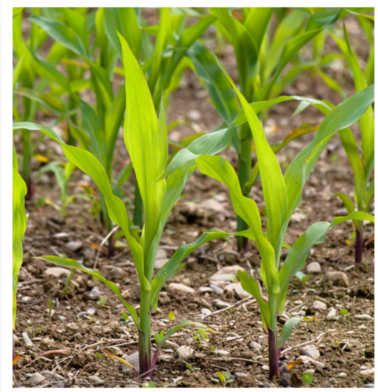
How do the most common GM crops affect the environment?

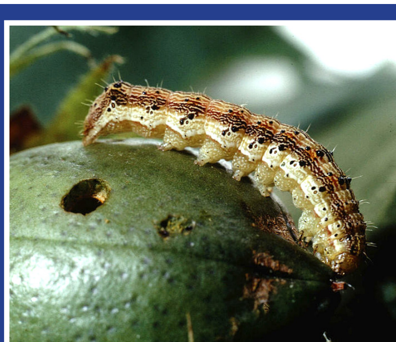
Genetically modified (GM) crops that can tolerate specific herbicides are hugely popular with U.S. farmers, accounting for 93% of soybean, 85% of corn, and 82% of cotton acres planted in 2013. Many farmers have come to rely heavily on the herbicide glyphosate (RoundUp®), which is less toxic than other common herbicides it replaced.



RoundUp Ready® (RR) crops and other herbicide-resistant GM crops have increased the use of no-till agriculture, which conserves topsoil and soil structure. Since weeds can be sprayed after RR crops are planted, farmers do not need to plow before planting saving labor, energy and topsoil.

These benefits may not last. If a field is sprayed every season, or repeatedly within a season, with the same herbicide, weeds that are slightly less susceptible to the herbicide may survive and possibly breed with other survivors. Over generations of weeds, the herbicide thus selects for greater and greater resistance to the herbicide, until the product becomes ineffective against that population, and is replaced or supplemented with other herbicides. In the case of glyphosate, the replacement herbicides are typically more toxic. In the United States, at least 14 weed species have evolved glyphosate resistance.

The other major category of GM crops are Bt crops that contain genes from Bacillus thuringiensis (Bt) bacteria. The Bt gene produces insecticidal proteins, which are the same insecticidal proteins used by organic and conventional farmers as pesticide sprays. Resistance to Bt was first reported in 1988 long before Bt GM crops were released. The development of insect resistance to Bt crops is a potential problem that is very dependent upon how Bt crops are grown and managed.



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Adoption of Bt Crops

Bt crops account for 75% of U.S. acres planted in cotton or corn. Many GM corn and cotton varieties contain both Bt- and herbicide-resistance genes. Adoption of Bt crops has led to a substantial decline in insecticide use—up to a 40% reduction in cotton, for example—as the pests targeted by specific Bt proteins have become less prevalent. In the case of corn, pesticide use and the farmers costs has also declined when compared to non-GM varieties, suggesting that the adoption of Bt varieties has lowered pest populations overall, to the benefit of all corn growers. This is a huge environmental benefit!

The Environmental Protection Agency requires that farmers who grow Bt corn and Bt cotton plant refugia (a refuge for susceptible insects), so that a percentage of their acres are planted with non-Bt varieties of the crop, creating a place where insects vulnerable to Bt can survive. This dilutes the pool of Bt resistance genes in the larger insect pest population and slows the evolution of pest resistance to Bt. The number of major insect pest species exhibiting newly evolved resistance to Bt increased from one in 2005 to five in 2010.

Evolving Challenges

The development of weeds resistant to glyphosate and insects resistant to Bt has not involved the movement of genes from crop plants to weeds or insects; instead, pests have naturally evolved their own resistance traits. This is a common phenomenon – many pests have evolved resistance to many pesticides over the years. For example, weeds have developed resistance to 22 of the 25 known sites of herbicides action and to 155 different herbicides including glyphosate.

Evaluating Crops

Planting herbicide resistant and Bt GM crops has yielded specific environmental benefits, in addition to reduced costs and energy needs. Ultimately, to evaluate these crops, we should consider their net environmental impacts. Do the benefits outweigh the impacts?

Positive Impacts

Our current evidence suggests that RR and Bt crops have had a positive overall ecological impact. RR crops have resulted in greater use of RoundUp®, but there has been a reduction in the use of more toxic herbicides, and soils have benefitted from reduced tillage. Bt crops have resulted in large reductions in insecticide use in cotton and corn. At the same time, some pest resistance has developed as use of these crops has expanded during the past two decades. In future bulletins, we will return to the question of whether these two common GM technologies demonstrate other non-target impacts.

Science, agricultural economics, and public policy will shape what contributions GM crops can make to sustainable farming. Various GM crops are currently being developed to address environmental challenges with higher temperatures and reduced water availability. New and improved varieties are crucial as the world's population approaches 9 billion people by 2040. GM traits such as drought resistance and increased yields may help maintain levels of agricultural production without having to exponentially expand the acreage under cultivation.

In our next bulletin, we'll examine concerns about the spread of GM traits from crop plants to other plant populations.