COLLEGE OF AGRICULTURAL, CONSUMER AND ENVIRONMENTAL SCIENCES

GMO Crops in New Mexico Agriculture

By Steve Hanson, Leslie Beck, Nancy Flores, Stephanie Walker, Mark Marsalis, and Richard Heerema[1]

aces.nmsu.edu/pubs • Cooperative Extension Service • Circular 682

The College of Agricultural, Consumer and Environmental Sciences is an engine for economic and community development in New Mexico, improving the lives of New Mexicans through academic, research, and extension programs.

All About Discovery!™
New Mexico State University
aces.nmsu.edu

GMO SHORT HISTORY/DEFINITION

People have been extensively modifying and improving crops since plants were first domesticated from wild relatives thousands of years ago. Traditionally, genetic traits in crops have been altered through a variety of means, including artificial selection, controlled cross-pollination and hybridization, and mutation breeding. The advent of genetic engineering in the 1970s gave plant breeders an additional tool for introducing specific desirable traits or removing specific undesirable traits from crop plant varieties. By removing or adding genes—sometimes from different, unrelated species—scientists can make targeted changes to plant genomes. Crops developed through genetic engineering are sometimes called *transgenic organisms* or *Genetically Modified Organisms* (GMOs).

GMO APPLICATIONS

The most widely adopted GMO crop varieties are those with introduced traits that directly benefit the farmers and livestock producers who grow food, fiber, and animal feed. These traits also indirectly benefit consumers through greater product availability and lower prices of agricultural products in stores. Such varieties have been genetically engineered for traits that aid farmers by protecting their crops against insect pest feeding, infection by plant diseases, or exposure to herbicides.

A gene called 'Bt' has been used in developing several GMO varieties of corn and cotton (among other crops) to make them resistant to certain damaging caterpillar- and grub-type pests (such as corn earworm; Figures 1 and 2) that are normally controlled using insecticides. These Bt varieties allow producers to maintain high yields while greatly reducing the amount of insecticide used. Squash and certain fruit tree species have been genetically engineered to give resistance to devastating plant viruses that are extremely difficult or impossible to control using

[1]Respectively, Associate Professor, Department of Entomology, Plant Pathology, and Weed Science; Extension Weed Specialist, Department of Extension Plant Sciences; Extension Food Technology Specialist, Department of Extension Family and Consumer Sciences; Associate Professor/Extension Vegetable Specialist, Department of Extension Plant Sciences; Extension Forage Specialist, Department of Extension Plant Sciences; and Extension Pecan Specialist, Department of Extension Plant Sciences.

Figure **1. Corn earworm is one of the pests commonly controlled with Bt varieties of corn.** (Photo courtesy of R.L. Croissant, Bugwood.org.)

Figure **2. The corn ears at the top and bottom are conventional varieties that were damaged by corn earworm, while the undamaged ears on the left and right are Bt corn varieties.** (Photo courtesy of Alton N. Sparks, Jr., University of Georgia, Bugwood.org.)

conventional methods. And GMO varieties of a wide range of field crops have been introduced that tolerate exposure to herbicides, such as glyphosate, that would injure or kill non-GMO varieties, allowing farmers to safely and more effectively manage weed competition with their crops. Different GMO traits can even be combined ("stacked") in a single crop variety for protection from multiple pests.

A number of GMO products have incorporated traits that directly benefit consumers. The oldest and best known of these are the "Golden Rice" varieties that were genetically engineered so that the rice kernels contain beta carotene, the same plant pigment that gives carrots and sweet potatoes their orange color (Figure 3). "Golden Rice" was developed with the goal of reducing vitamin A deficiencies, particularly among poor and vulnerable people around the globe. More recently, the Arctic® series of apple varieties and Innate® series of potato varieties have been genetically engineered to retain product quality longer after harvest, thereby improving the consumer's experience and reducing food waste. Innate® potatoes have the added health benefit of producing lower levels of toxic acrylamide during cooking compared to non-GMO potatoes.

As is true throughout the U.S., most GMOs grown in New Mexico are used for fiber (i.e., cotton) and animal feed (e.g., corn, alfalfa, and soy). Chief among these are the herbicide-tolerant and Bt varieties mentioned above that benefit producers by simplifying weed control and enabling more sustainable production practices. Other GMO varieties soon to be introduced that may have significance for New Mexico include alfalfa that has been engineered to be more palatable and digestible for livestock.

GMO CONSIDERATIONS

When deciding to adopt new technologies, consumers, scientists, and government regulators must consider the balance of the positives and negatives that the new technology brings to our lives. This certainly applies to genetic engineering, which is why GMOs are always subjected to thorough testing by multiple federal agencies (USDA, FDA, EPA) before they are released for use in agriculture. In fact, GMO crops are more thoroughly tested than other plant products on the market (NASEM, 2016).

Nonetheless, many in the public continue to have concerns about health issues associated with consuming GMOs. A lack of understanding—and some misinformation—about genetic engineering has perpetuated these fears and limited the benefits that GMO crops can provide. Rigorous peer-reviewed studies have repeatedly shown GMO crops to be as safe as their conventional counterparts (NASEM, 2016). There is even good scientific evidence that certain GMO foods may be safer than their conventional counterparts due to reduced levels of pesticide residues and toxins (NASEM, 2016).

These academic studies are being confirmed by real-world experience, as shown in one recent comprehensive study, nicknamed "The Trillion Meal Study." Published in the *Journal of Animal Science* in 2014, this study examined livestock health records from over 100 billion poultry and livestock animals, comparing numerous health and productivity measures for animals that had been fed either GMO or conventional food. They found no adverse animal health outcomes that were associated with GMO feed use (NASEM, 2016; Van Eenennaam and Young, 2014).

***Figure* 3. The "Golden Rice" variety (left) has been engineered so the rice kernels produce beta carotene, which can help reduce vitamin A deficiencies.** (Photo courtesy of International Rice Research Institute.)

Although the safety of consuming GMO crops is well established, other potential agricultural and ecological concerns do remain (NASEM, 2016). The most serious of these is pesticide resistance. Pests have been adapting to pesticides for as long as these materials have been used, and this problem is not unique to GMO cropping systems. However, this issue could actually be accelerated by GMO traits focused on weed and insect control that place evolutionary selection pressure on pest species. As in non-GMO cropping systems, the thoughtful use of integrated pest management strategies with GMO crops will be essential for maximizing the useful life of GMO technology and critical pesticides, and minimizing selection of resistant pests.

Another potential source of concern is the transmission of genes through cross-pollination from GMOs to non-GMOs, including organic crops, other conventional crops, weeds, and native plants. Careful planning by producers, including adequate spacing and the use of border crops, minimizes risk of cross-pollination between GMO and non-GMO crop stands and plants.

GMO crops also raise economic concerns associated with large-scale conventional agriculture, including the loss of crop genetic diversity and expanding corporate influence over agriculture. These concerns are not inherent to GMO crops, but are a reflection of the continued evolution of our food systems toward more consolidated production supported by fewer and fewer companies.

Consumers rightly feel that they should be able to know what is in their food. Labeling of GMO foods is therefore a serious issue for many consumers. The U.S. has long had strong food labeling regulations to provide consumers with detailed and substantive information, including both the ingredients and nutrition facts, for the products they purchase. One criticism of GMO labels is that they could fail to inform consumers about the specific traits added to or removed from the food. Thus, GMO labels could be mistakenly interpreted as vague warnings rather than providing any specific information for consumers to make educated decisions about the foods they consume.

There have been several state- and national-level GMO labeling initiatives, and a federal GMO food labeling rule requiring manufacturers to indicate the presence of GMO ingredients was signed into law in July 2016 (Jalonick, 2016). Consumers interested in avoiding GMO foods for any reason are currently able to do so by purchasing foods labeled as "Certified Organic" or "Non-GMO Verified."

GMO crops have been, and will continue to be, a controversial topic in agriculture, including in New Mexico. They have been widely adopted because of the clear benefits these crops provide producers and their employees, farming communities, the environment, and consumers. At the same time, organic and other non-GMO producers are also an important part of New Mexico's agricultural community. Expanding the awareness of the science surrounding GMO crops will be important for informing consumers and developing policies that support our centuries-long heritage of agriculture in New Mexico.

GMOs—FREQUENTLY ASKED QUESTIONS

Q: What are genetically modified organisms (GMOs)?

A: Genetically modified organisms (GMOs) are organisms whose DNA has been changed through genetic engineering techniques. Products from GMOs are common in many facets of our everyday lives. In agriculture, most GMO crops are used for livestock feed or textile fiber, but some GMO food products do exist.

Q: How do we really know GMOs are safe?

A: There is a widely held misconception that the health effects of GMOs have never been well examined. The fact is, however, that GMO crops have always been rigorously and extensively tested. GMO crops must be approved by three different federal agencies (USDA, EPA, and FDA) prior to use in agriculture, which means they are among the most carefully tested food products on the market. In addition, several studies examining real-world data on the health effects of these crops after their release have also been performed. These include the "Trillion Meal Study" and a report from the U.S. National Academy of Sciences, both of which found no evidence that foods from GMO crops were less safe than foods from non-GMO crops (NASEM, 2016; Van Eenennaam and Young, 2014). Genetic engineering technology may, in fact, create healthier foods. For example, GMO field crops with improved lipid profiles are being developed to create more healthful vegetable oils (NASEM, 2016).

Q. My family has food allergies. Will GMO foods increase our risk of allergic reactions?

A: Food allergies are a serious concern in our food system. Foods are extremely complex substances that contain thousands of different compounds. Allergic reactions are immune responses that some people have to one or a few of these compounds—called "allergens"—in the food they consume. While food allergies are relatively rare and most people have no reaction to most foods they eat, food allergies can cause serious health concerns, and even death, in allergic individuals. All of the known food allergies are caused by allergens already present in conventional non-GMO crops. The allergy potential of GMO crops has always been considered when developing and testing these crops. In fact, the UN's World Health Organization (WHO) and Food and Agriculture Organization (FAO) both have clear guidelines that specifically call for avoiding the introduction of known allergens into GMOs (WHO, 2014). Further, follow-up studies looking for new allergies in the population are also performed after the introduction of GMO crops. To date, there has not been a single confirmed case of an allergic reaction to a GMO trait in any human or livestock animal (NASEM, 2016; WHO, 2014).

An exciting potential use of genetic engineering technology is its application to actually remove allergens from our food. While no hypoallergenic GMO varieties have been approved for production at this time, research is underway using genetic engineering technology to remove allergens from peanuts, wheat, and other crops.

Q: What GMO crops are being grown in New Mexico?

A: GMOs make up the majority of corn, cotton, and soybeans grown throughout the U.S. GMO technology is also emerging in other crops like alfalfa, apple, sugar beet, potato, canola, and rice (a comprehensive list of GMO crops approved for use in the U.S. is available online at http://nmsu.life/GMOlist). GMO corn, cotton, and alfalfa are being grown in New Mexico, and New Mexican producers are permitted to grow other GMO crops approved for use in the U.S.

Q: Are there any GMO chiles being grown in NM?

A: The chile industry faces a number of challenges that could be alleviated through the use of GMOs. For example, the development of disease-resistant chile varieties would reduce loss to diseases that growers currently have no means of preventing. However, no GMO chile varieties have been developed or approved for use in New Mexico. In fact, to date there are no GMO chile varieties that have been approved for use anywhere in the U.S.

Q: Are GMO crops reducing the diversity of plants we use in agriculture?

A: Loss of diversity in crop plants was a problem in agriculture long before the introduction of GMO crops. The research and development costs for crop genetic improvement have driven companies to focus on producing more seed from fewer crop varieties, which has led to a dramatic loss of crop diversity and even extinction of valuable varieties over the past century. This is especially true for hybrid crop varieties. Given the extra costs associated with development and the testing required for approval of GMO crop varieties ($10–100 million per variety), this trend is likely to continue for both conventional and GMO crops. This long-recognized problem has spurred a movement for crop variety preservation. These efforts include many privately funded and government-supported efforts to ensure the preservation of our precious genetic resources in both native and crop plants. Examples include Native Seed/SEARCH (http://www.nativeseeds.org), a private, nonprofit organization that specializes in plants from the Southwest; the USDA's Center for Agricultural Resources Research and National Clonal Germplasm Repository programs; and the Svalbard Global Seed Vault in Norway. This interest in crop diversity is also evident at the consumer level with the growing popularity of boutique and organic food products.

Q: Can pollen from GMOs contaminate non-GMO crops?

A: Cross-pollination between different crop varieties of the same species grown near each other has been a long-standing problem in agriculture and is not unique to GMO crops. For instance, studies have shown that heritage chile varieties are often contaminated by conventional pepper varieties. Cross-pollination by GMO varieties is a concern for organic growers since cross-pollination could disqualify the crop from bearing the Certified Organic label. The good news is that the factors governing cross-pollination are well understood, and keeping plant lines genetically pure is relatively simple. Maintaining adequate space between plantings can prevent most cross-pollination. This is the reason that most professional breeders and seed production companies grow seed lots in isolated blocks that have field borders. Seed cages to exclude outside pollinators can also be used to maintain genetically clean lines. NMSU Extension specialists with expertise in this area are happy to provide advice on preventing cross-pollination and maintaining genetically pure lines.

Q: Are GMO crops causing harm to beneficial insects like honey bees?

A: The importance of beneficial insects in agriculture cannot be overstated, and there is legitimate concern over the population decline of some important insect species, as exemplified by Colony Collapse Disorder in bees. In particular, many people wonder if the GMO Bt crops used to control agricultural insect pests are harmful to beneficial insects, especially bees. Research has shown that Bt crops are not harmful to bees or other beneficial insects for several reasons. Since the Bt genes are only expressed in the plant, only those insects that actually consume the plant are affected. Further, the Bt genes are highly specific for the insects they control. Several different Bt genes are on the market, some for the control of caterpillar-type insects and some for beetle-type insects. Neither of these have insecticidal effects on other unrelated insect species like honey bees. In fact, the Bt genes can allow reduced insecticide use in crop fields, which aids the conservation of beneficial insects (NASEM, 2016). Researchers have also assessed the effects of herbicide tolerance on bees. A recent study, published in the *Journal of Economic Entomology*, concluded that glyphosate has "very minor or no acute toxicity to honey bees" (Zhu et al., 2015). So far, research studies have not found a correlation between glyphosate and Colony Collapse Disorder.

The critical role these insects play has been taken into account during the development, testing, and approval for all the GMO crops in use today.

Q. Are monarch butterflies impacted by Bt crops that target caterpillar-type insects?

A: Initially, there were concerns that Bt corn pollen could negatively impact monarch butterfly populations. Subsequent research has shown that while Bt corn pollen is indeed toxic to monarch caterpillars, they are unlikely to ingest sufficient corn pollen in the wild to be affected, even when feeding on milkweed adjacent to Bt cornfields. While more research on monarchs and other butterfly species is necessary, results to date suggest that recent declines in monarch populations are likely due to the loss of suitable habitat and the monarch's milkweed food source rather than the planting of Bt corn (NASEM, 2016; Pleasants and Oberhauser, 2013).

Q. Are GMO crops better quality than their non-GMO counterparts?

A: Yes and no. In general, GMO food and animal feed products are nutritionally equal to their non-GMO counterparts. However, some aspects of quality may be improved in GMO production systems. For example, Bt crops can have lower insecticide residues and reduced insect damage. Foods with extended shelf life, like Arctic® apples and Innate® potatoes, may also provide quality advantages that are attractive to consumers. Improved weed and insect control in GMO crops can also significantly improve the quality of livestock feed. For instance, Roundup Ready® alfalfa can simplify the production of forage with high nutritive value that contains less contamination with hard-to-digest, low-nutrition, and potentially toxic weeds. The potential release of easier-to-digest GMO, low-lignin alfalfa may also provide nutritional benefits to livestock. Similar benefits may be derived from GMO corn varieties grown for grain and silage.

Q: Is it true that GMO crops fail to out-yield conventional non-GMO crops?

A: It is a common criticism that GMO crops generally do not out-yield non-GMO crops. This is a misleading criticism because GMO crops on the market today were not actually developed to increase yields. Rather, most GMO crops in use today were intended to *maintain* yields under circumstances that cause yield losses in conventional non-GMO crops. For example, GMO papaya with resistance to the Papaya ringspot virus does not out-yield conventional papaya when the disease is absent, but these GMO papayas avoid devastating losses when the disease is present. In fact, this technology is credited with saving the papaya industry in places like Hawaii where the ringspot disease is established (Gonsalves et al., 2004). Herbicide-tolerant and insect-resistant GMO crops can provide similar benefits in the face of weed or insect pest pressure. GMOs with improved quality traits, like Arctic® apples or Innate® potatoes, are not expected to yield differently than their conventional counterparts, although the extended shelf life traits of these products may reduce product losses after harvest. While the GMO crops on the market today do not necessarily out-yield non-GMO varieties, many GMO traits can allow crop yields to be maintained under conditions that substantially reduce yields in non-GMO crops.

Q: Do GMO crops increase pesticide use?

A: The answer to this question depends entirely on the GMO trait being used. Bt crops, for example, significantly reduce the amount of insecticide used in crop production. On the other hand, many GMO crops, like Arctic® apples and Innate® potatoes, are not expected to affect pesticide use at all. Herbicide-tolerant crops, however, were designed for use with pesticides and are therefore associated with increased herbicide use. The most common GMO herbicide-tolerant crops used are those with tolerance to glyphosate, which is known to have lower human toxicity and reduced environmental impact compared to many of the herbicides it replaces. In this case, the GMO system potentially reduces the amount of more toxic herbicides released in the environment. Overall, GMO production systems offer the potential to reduce the impacts of pesticides used in agriculture (NASEM, 2016).

Q: Is it true that biotech companies are making Agent Orange-resistant GMOs?

A: Definitely not! This is one of the more blatant mistruths spread to create fear over GMO crops. Given the known danger associated with Agent Orange, it is highly unlikely that government regulators would ever approve such a crop or that any biotech company would try to develop one. Agent Orange was a mixture of two herbicides, 2,4-D and 2,4,5-T, used as a defoliant to aid our troops during the Vietnam War. Unfortunately, the 2,4,5-T included in Agent Orange was contaminated with highly toxic chemicals called dioxins that caused a range of acute and chronic conditions, including skin burns, cancer, birth defects, and death.

2,4-D was one component in Agent Orange, but was not responsible for its toxicity. 2,4-D has been used in lawn care products, city park maintenance, and agriculture for over half a century and has a low toxicity profile for humans. Biotechnology companies are now developing 2,4-D-tolerant plants, similar to the glyphosate-tolerant plants currently in use. Rotating between glyphosate-tolerant and 2,4-D-tolerant crops could help farmers curb the selection for herbicide-tolerant weeds. Nevertheless, 2,4-D does pose some known ecological/agricultural concerns (due to drift onto non-target plants) that should be carefully evaluated before adopting this strategy. So, although 2,4-D was one of the components in Agent Orange, no company is developing Agent Orange-resistant crops or planning on introducing dioxins into our food production system.

Q: I am against eating GMOs. How can I avoid eating any GMO foods?

A: Some people are philosophically opposed to eating GMOs despite the lack of any proven health risks. That is certainly their right! Avoiding consumption of GMO foods is easy. Most GMO crops on the market today are used for textile fiber or livestock feed, but knowing which GMO crops are on the grocery store shelf can help. In the produce aisle of the grocery store, these include some sweet corn and summer squash and most papaya produced in Hawaii. Some processed foods contain high fructose corn syrup (or many other corn-based ingredients), soy, canola oil, cottonseed oil, or beet sugar, all of which are likely to have been derived at least in part from GMO crops. The simplest way to be sure of avoiding GMO food is to buy foods labelled as non-GMO or Certified Organic. “GMO free” labels are becoming a common way for producers to advertise the GMO-free nature of their foods to interested customers. Producing food in your home garden from non-GMO seed is also an excellent way to be certain that your food is non-GMO.

Q: Are agricultural crops the only area where GMOs touch our lives?

A: We actually use a wide variety of products derived from genetically engineered organisms in many areas of our lives. Enzymes for uses as diverse as contact lens cleaner and cheese production are produced from GMO bacteria or fungi. Likewise, medicines ranging from insulin to human clotting factor for treatment of hemophilia to therapeutic antibodies that are the cutting edge of cancer therapy are among the many biotech products used in modern healthcare.

REFERENCES AND FURTHER READING

Gonsalves, C., D.R. Lee, and D. Gonsalves. 2004. Transgenic virus-resistant papaya: The Hawaiian ‘Rainbow' was rapidly adopted by farmers and is of major importance in Hawaii today. *APSnet*. Available at http://www.apsnet.org/publications/apsnetfeatures/Documents/2004/HawaiianRainbow.pdf

Jalonick, M.C. 2016, July 29. Obama signs bill requiring labeling of GMO foods. *U.S. News & World Report*. Available at http://www.usnews.com/news/business/articles/2016-07-29/obama-signs-bill-requiring-labeling-of-gmo-foods

National Academies of Sciences, Engineering, and Medicine (NASEM). 2016. *Genetically engineered crops: Experiences and prospects*. Washington, D.C.: The National Academies Press. doi: 10.17226/23395. Available at https://www.nap.edu/read/23395/chapter/1

Pleasants, J.M., and K.S. Oberhauser. 2013. Milkweed loss in agricultural fields because of herbicide use: Effect on the monarch butterfly population. *Insect Conservation and Diversity*, 6, 135–144.

Sears, M.K., R.L. Hellmich, D.E. Stanley-Horn, K.S. Oberhauser, J.M. Pleasants, H.R. Mattila, B.D. Siegfried, and G.P. Dively. 2001. Impact of *Bt* corn pollen on monarch butterfly populations: A risk assessment. *PNAS*, 98, 11,937–11,942.

Van Eenennaam, A.L., and A.E. Young. 2014. Prevalence and impacts of genetically engineered feedstuffs on livestock populations. *Journal of Animal Science*, 92, 4,255–4,278.

World Health Organization. 2014. Frequently asked questions on genetically modified foods. Available at http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/

Zhu, C.Y., J. Adamczyk, T. Rinderer, J. Yao, R. Danka, R. Lurrell, and J. Gore. 2015. Spray toxicity and risk potential of 42 commonly used formulation of row crop pesticides to adult honey bees (Hymenoptera: Apidae). *Journal of Economic Entomology*, 108, 2,640–2,647. http://dx.doi.org/10.1093/jee/tov269

Brand names appearing in publications are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.