College of Agriculture, Food and Environment
Cooperative Extension Service

Plant Pathology Fact Sheet **PPFS-MISC-07**

Genetically Engineered Crops— A Review of Concerns and Benefits[1]

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As the global population increases, there is an ever-greater need for increases in crop yields on the same amount of land. In addition, an increased focus on food safety, sustainability, reduced agricultural inputs, and reduction of pesticides, puts further pressure on crops and growers. Thus, some have turned to genetically engineered crops as a way to meet the demands of a changing world.

The genetic modification of plants is nothing new, as nature genetically modifies organisms in bizarre and remarkable ways through natural changes over time (Example 1). Humans have guided genetic changes in crops for thousands of years through simple selection. Conventional plant breeding is based on the selection of individual plants with desirable traits and transfer of these traits into a population. Conventional breeding techniques produce changes to the crop's DNA, but usually with less precision than genetic engineering. However, conventional breeding techniques are still very useful.

Genetically engineered crops are plants that have had their genetic material (DNA) purposefully manipulated in the laboratory to produce a particular beneficial outcome. These types of crops are often called genetically modified organisms, or GMOs. Commercial genetically engineered crops are designed to have limited and precise genetic changes that provide one or more benefits to humans or the environment.

Genetic engineering has been part of American life for decades. Genetically engineered corn has been grown in the USA since 1996. Most genetically engineered crops are not consumed directly by humans, but rather are used for animal feed, processing, or for fuel production. Although there are no new hazards from consuming GMO crops, those that wish to avoid all foods derived from genetic engineering can buy certified organic foods or those specifically labelled to be GMO-free.

The manipulation of the genetic make-up of crops raises numerous concerns and questions for many consumers. Should these products be regulated? Are they safe? What are the benefits of GMOs? The following aims to provide an unbiased review of the concerns and benefits of genetically engineered crops based on the research available on the topic.

Example 1— Sweetpotato: Genetically Engineered by Nature

Sweetpotato, an example of a natural GMO.

Transfer of genes from one organism to another seems bizarre, but this happens regularly in natural ecosystems. It is one way that nature creates biodiversity. Scientists have recently reported that sweet-potato naturally contains at least four genes from a soil-dwelling bacterium. Examples of natural gene transfer are common in the scientific literature, and more are being discovered regularly as science advances.

[1] Summarized from the UK publication *Genetically Engineered Crops: Emerging Opportunities* (PPA-47) by Kimberly Leonberger, Extension Associate

Concerns Expressed About Genetic Engineering

Is genetic engineering natural?

Nature commonly and naturally produces dramatic changes in the genetics of plants. In making dramatic changes in DNA, nature creates biodiversity. Laboratory techniques of genetic engineering were developed by studying the creative things nature does with DNA.

Are genetically engineered crops safe to eat?

- Genetically engineered crops grown in the USA are subjected to detailed scrutiny for safety to humans and the environment. The U.S. Department of Agriculture, the U.S. Food and Drug Administration, and the U.S. Environmental Protection Agency evaluate the safety of genetically engineered crops. In contrast, non-engineered (non-GMO) crop varieties typically receive very little to no formal evaluation by government agencies.
- Many scientific experts worldwide agree that genetically engineering a crop generally presents no new health risks that cannot also arise from conventional plant breeding.
- Certain genetically engineered traits can actually improve the safety of food (Example 2).
- There is ongoing scientific discussion over crops engineered to be tolerant to the weed-killer called glyphosate. Numerous studies show no significant health risk to humans from government-approved uses of glyphosate. However, some experts do raise questions about the safety of long-term exposure to glyphosate in the diet. This is one reason some want products derived from genetically engineered crops to be labeled.

Can genetic material from genetically engineered crops spread in pollen?

- Genetically engineered genes may move into wild relatives of crops plants when pollen from the genetically engineered crop lands on the flowers of a wild relative. Genes that are foreign to native plant species may be introduced through the pollen. Such gene spread could negatively impact biodiversity in some instances. No such cases have been documented to date.
- Genetically engineered genes may move into fields of producers growing crops intended to be free of genetically engineered genes. There is some evidence that this has happened in traditional varieties of corn grown by smallholders in Mexico. Although there is still some scientific uncertainty that this has happened, many scientists are concerned about the possibility. There is evidence of transgene spread into a canola field in Australia intended for organic certification, which resulted in unpleasant litigation. Instances like these highlight a significant challenge for the use of those genetically engineered traits that may spread in pollen.

Example 2—Improving Food Safety through Genetic Engineering

Fungal growth of Fusarium ear and kernel rot of corn that can result in contamination by mycotoxins.

In some cases, engineered crops can be safer than conventional foods. Corn grain can be naturally contaminated by mycotoxins, which are toxins produced by fungi. Mycotoxins pose health risks to livestock and humans. Several types of livestock are subject to poisoning by mycotoxins, which can result in death. Human exposure to these compounds has been linked to specific birth defects, esophageal cancer, and liver damage.

One way corn growers can reduce the level of mycotoxin contamination is through the use of varieties with a Bt trait. The fungi that result in mycotoxins often invade grain through wounds, such as those that result from insect feeding. Bt traits can reduce insect feeding and limit wounds that could be colonized by mycotoxin-producing fungi.

Do patents on seeds or genetic traits cause concern?

- The majority of acreage planted to genetically engineered crops in the USA is/was patented by multinational corporations. Federal laws allow for such patents to help protect the investment of those that develop new genetic technologies. Farmers may not save seed from a patented genetically engineered crop.
- The cost of legally using a patented genetically engineered trait can increase the cost of crop production. In developing countries, resource-poor farmers and indigenous peoples often prefer seed that is not genetically engineered. However, in

developed nations, many farmers choose to pay for the genetically engineered seed because they value its agronomic performance.

- Some are concerned about corporate control of the food supply. Patents on genetically engineered crops have played a part in the consolidation of the global seed industry in recent decades. The beginnings of the consolidation of the seed industry occurred decades before the first genetically engineered crops. Furthermore, large corporations do not own all genetically engineered traits. Some are developed by public research institutes and humanitarian foundations. Patents on genetically engineered traits do not last forever. Once a patent expires, the genetically engineered trait is in the public domain.

Are food cultures affected by genetically engineered crops?

Some people believe that the use of genetically engineered crops conflicts with their regional food culture, which may have a foundation in centuries of history.

Does genetic engineering foster monoculture farming?

Large-scale monoculture offers important advantages to farmers and consumers. To some extent, genetic engineering can foster monoculture. However, monoculture is not caused by genetically engineered crops. Indeed, monoculture farming existed long before genetically engineered crops were first created, and monoculture is commonly practiced today on non-genetically engineered crops throughout the world. An important down-side of monoculture is it's potentially subject to destructive outbreaks of diseases and insect pests.

Do genetically engineered crops cause loss of biodiversity?

Biodiversity in non-agricultural ecosystems (=wild diversity). To date, there are no reports of direct negative impact on biodiversity from genetically engineered crops in ecosystems surrounding farmlands. The National Academy of Sciences concluded, "Generally, GE (genetically engineered) crops have had fewer adverse effects on the environment than non-GE crops produced conventionally." This is in part because certain genetically engineered crops can reduce pesticide use, which helps protect the ecosystems surrounding farms. However, one can never rule out the possibility of negative ecological effects from genetically engineered crops, especially through movement of engineered genes in pollen.

Biodiversity in agroecosystems (=domesticated diversity). The concern with genetically engineered crops is that they will displace traditional varieties, resulting in erosion of crop genetic diversity. However, useful genetically engineered genes can commonly be moved (by conventional breeding) into locally adapted varieties. Thus, genetically engineered crops do not necessarily cause a loss in local diversity of crop genetics.

Do genetically engineered crops promote pesticide use?

- Many emerging genetically engineered traits have no impact on pesticide use. Certain genetically engineered traits can reduce pesticide use (Examples 3 & 4). More pesticide-reducing

Example 3—Genetically Engineered Crops that Reduce Pesticide Use

Many research programs are developing genetically engineered traits that make plants resistant to important diseases and insect pests. With an increased tolerance to diseases and pests comes a reduction in pesticide use. Many of these genetic traits come from crops already in the food supply, meaning a new variety can be made more disease-resistant by transferring one or more genes from another variety, or from a close relative. For other genetically engineered crops, resistance genes may come from other crop species or organisms. While it might be possible to produce the same outcome with traditional breeding, genetic engineering can often produce these new varieties faster, result in less genetic disruption to the original variety. Genetic engineering also can provide the ability to insert multiple beneficial genes at once ("stacking"), which could result in a more durable resistance.

Some crop production systems are dependent on pesticide applications. Genetic engineering is expected to continue to help reduce pesticide use.

Example 4—Plants that Fight Back Against Insects

Corn at left with Bt trait, which protects against fall armyworm damage. Conventional corn at right showing significant damage from fall armyworm.

The bacterium, *Bacillus thuringiensis,* which is often abbreviated Bt, produces insecticidal proteins that can be used for insect control. Bt proteins bind to the gut of insects, eventually killing them. Certain genetically engineered crops produce one or more Bt proteins in the plant. These crops need less insecticide than conventional counterparts, resulting in less pesticides in the environment, greater survival of beneficial insects, and less pesticide in our diets. Bt proteins pose an extremely low risk to humans, as they are less toxic than common table salt.

One concern about Bt crops is the possibility of insect resistance to pesticides that use live *Bacillus thuringiensis* or Bt-derived proteins. Farmers often use practices to reduce the risk of insect resistance to Bt toxins, but the widespread use of Bt engineered crops does present risks for the development of insect resistance.

genetically engineered traits are expected in the future, especially for control of diseases and insects.

- There are concerns that the use of herbicide tolerant crops can lead to increased herbicide use over the long term. There also is concern that overuse of a single genetically engineered trait for pest control may erode its effectiveness over time, through the buildup of resistant pests.
- It is important to distinguish genetic engineering (which is a form of crop breeding) from risks due to the pesticides that may be applied to engineered crops.

Benefits of Genetic Engineering

Human health and nutrition

- Genetically engineered crops are being developed to alleviate food allergies. For example, research is creating genetically engineered wheat with greatly reduced gluten content. If successful, genetically engineered wheat may allow those suffering celiac disease to enjoy foods normally made with wheat flour.
- Some genetically engineered crops under development are designed to alleviate serious nutrient deficiencies in humans, especially in the developing world. There are several genetically engineered crops designed to alleviate deficiencies of Vitamin A, folate, Vitamin C, iron, and other micronutrients and minerals.
- Toxic substances occur naturally in our foods, whether conventional or organic. Many of these substances are produced naturally by plants as they grow. Others are formed during food preparation. Certain genetically engineered crops can have considerably lower concentrations of naturally occurring toxins, such as mycotoxins, which can have serious health impacts.
- Genetically engineered crops can be developed to have high amounts of healthy oils. For example, a variety of soybean has been engineered to produce high amounts of a healthy oil called oleic acid.

Less pesticide

Studies have shown reductions in pesticide use through the use of certain genetically engineered crops, such as those engineered to produce Bt protein. This has important benefits to consumers (less pesticide residues on foods) and the environment (less contamination of ecosystems). Significant benefits for farmers and farm workers include less exposure to pesticides and fewer pesticide poisonings.

Environmentally friendly pest control

Certain genetically engineered crops are designed to be resistant to damaging insects and diseases (Examples 5 & 6). This can help increase yield as well as reduce pesticide use. Some genetically engineered crops, which require few insecticides, promote the buildup of natural enemies of destructive insect pests.

Lower environmental footprint

Most scientists believe that present and future genetically engineered crops can help reduce the environmental footprint of our food system. Genetically engineered crops currently under development are expected to use fertilizer and irrigation more efficiently, reducing the impact of farming on water quality and water supplies. Others are expected to reduce emissions of greenhouse gases. Still others are expected to reduce food waste, which will have important environmental benefits.

Example 5—Restoring the Once-Mighty American Chestnut

Fallen chestnut tree.

The American chestnut was one of the most common and valued trees in North American forests before it was nearly wiped out by a non-native, invasive fungal disease, called chestnut blight. For over a century, conventional disease-control approaches have failed to undo the damage caused by chestnut blight. However, researchers have made a significant advance that may help in American chestnut restoration. A single gene from wheat, transferred into American chestnut, makes it highly resistant to the damage caused by the chestnut blight fungus. Presently, this genetically engineered American chestnut is undergoing federal review.

Example 6—Saving Florida Oranges

Citrus tree exhibiting citrus greening.

Citrus greening is a highly destructive disease that invaded Florida in 2005. Since its detection, 135,000 acres of Florida citrus production have been abandoned due to citrus greening, and there is concern that the state eventually will lose most of its citrus production. To date, conventional disease-control techniques, including breeding, have performed poorly. Recently, a single gene from spinach was inserted into an orange plant and the new variety has exhibited a high level of resistance to citrus greening. The new orange variety is currently undergoing federal review.

Soil conservation

Use of certain genetically engineered varieties can facilitate the expansion of no-tillage agriculture in some crops. This protects the land from erosion and helps promote healthy soils. No-tillage farming may also increase natural carbon storage in soils, which helps to mitigate climate change. Finally, no-till farming helps protect rivers, lakes, and streams, by reducing runoff of nutrients and soil that pollute surface waters.

Increased yield

Numerous studies have found yield increases associated with the use of genetically engineered crops due to improved insect and weed control. Conventional breeding also produces yield increases, so crop improvement benefits from both conventional techniques and from genetic engineering.

Reduced labor costs

Genetically engineered crops that allow for pesticide reductions often mean that labor costs are reduced. It is important to note that reduced labor needs may affect local employment, which can be a negative consequence of improved farming efficiency.

Higher profits

Many times, farmers' profits are higher with genetically engineered crops. In developed countries, this helps support farmers, while in developing countries, higher profits mean greater food security and a better quality of life for farm families.

Stress-tolerant crops

Farmers must produce crops under the environmental stresses of a changing climate. Genetically engineered traits are being developed to protect against those stresses, including crop tolerance to flooding, drought, and temperature extremes.

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