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GENETICALLY MODIFIED CROPS

INTRODUCTION

The development of genetically modified (GM) crops in the United States has become an increasingly controversial topic due to consumer safety and environmental concerns. Labeling in particular is an issue. In 2007, Alaska enacted a law requiring all GM fish and fish products to be labeled and many other states have recently considered legislation that would require any food containing GM organisms to be labeled. No similar bills have been introduced in Wisconsin. This brief provides background on GM crops, the major issues of debate, and what is being done on the state and federal level to regulate GM crops.

HISTORY OF GENETIC MODIFICATION

For several thousand years, farmers have utilized techniques to improve crop quality and reduce the negative impacts of insects and weeds on crops. Gone unchecked, insects and weeds can cause crop failure or a decline in harvest. Traditional methods of achieving desired crop traits have relied on natural selection and selective breeding where farmers would keep the seeds from previous successful crops for later reuse. In some circumstances, traditional methods have provided adequate crop success. However, such methods rely on existing genetic variations within a species and may take several years to achieve a desired crop trait.

Herbert Boyer and Stanley Cohen demonstrated that DNA could be transferred across species by successfully transferring frog DNA into bacterial cells in 1973. Their study was the first to demonstrate that DNA could be transferred across species. This advancement in genetics has allowed scientists to alter crop DNA and achieve desired traits. Such traits can include resistance to disease, insects, and herbicide; an increase in nutritional value and shelf life; and certain taste and cosmetic characteristics. Many traits have the potential to increase crop yield, allowing farmers to produce more product without needing additional land. Although genetic advances have provided farmers with new breeding methods, some concerns have been raised as to whether or not genetically modified crops should be used for human consumption.

The FDA approved the first GM crop, known as the Flav'r Sav'r™ tomato, for human consumption in 1994. The tomato was modified to prolong maturation, which prevented it from over ripening before arriving at the supermarket. Since the tomato's introduction, the market for GM crops has grown to include crops such as corn, soybeans, and cotton. As a result of the increased growth of GM crops, many processed foods such as cereals, soft drinks, and chips contain ingredients derived from such crops.

GENETIC ENGINEERING

Crops can be genetically engineered by artificially inserting genes known as "transgenes" from one organism to another, known as the "host." One method of insertion of new genes may be achieved using a "gene-gun." The gene-gun technique utilizes biologically inert particles (meaning they will not react with any biological substance) such as gold or tungsten atoms. The particles are coated with the desired genes. The particles are "shot"

Prepared by Jenni Le, Legislative Analyst

into the host's plant tissue, which incorporates the new DNA material into the plant's DNA. Another method of gene insertion utilizes the soil bacterium known as *Agrobacterium tumefaciens*, which contains the necessary cellular components to transfer DNA from one species to another. Once a transgene is incorporated into a GM crop's DNA, the crop will express the trait regulated by the transgene.

TYPES OF GM CROPS

The GM crop profile in the United States largely consists of corn, soybeans, and cotton. Herbicide-tolerance, insect-resistance, and stacked-gene varieties are the most common modifications found in the commercial market. Stacked-gene varieties combine herbicide-tolerance and insect-resistance into one plant. In recent years, the adoption of crops that contain stacked genes has risen substantially. The United States Department of Agriculture (USDA) reports that as of 2012, 52% of corn and 63% of cotton acres are composed of stacked-gene varieties.

Herbicide-tolerant (HT) crops are engineered to survive certain types of herbicide applications. Farmers commonly apply herbicide to crops in order to prevent weeds from outcompeting crops for resources such as nutrients, space, and light. Crops that have been genetically modified to resist herbicide allow farmers to use weed chemicals on their crops without worrying about the herbicide affecting the crop.

Insect-resistance is also commonly found in several GM crops. Insect-resistant crops are engineered to contain a gene from a soil bacterium known as BT (*Bacillus thuringiensis*). Once the gene is integrated into the crop genome, the BT gene causes the crop to produce BT toxin, which kills insects such as the European corn borer, root worm, and corn ear worm. An insect-resistant GM crop is thus protected from any insect affected by BT toxin.

Current research on GM crops suggests a possibility of one day having crops that are tolerant to extreme weather conditions such as drought, heat, or freezing. In addition to weather tolerance, future crops could be engineered to produce vaccines, biofuels, and higher nutrient content.

GM CROP DEBATE

The debates for and against the production of GM crops include safety and environmental issues. Proponents argue that GM crops are safe for human consumption, are environmentally sound, and could aid in the fight against malnutrition. Opponents argue that GM crops pose a health risk for consumers and cause environmental degradation. In recent months, both parties have expressed ideas and concerns about labeling initiatives.

Proponents believe that GM crops, such as BT corn and cotton, provide a safe alternative to using insecticides and other toxic chemicals which have been shown to negatively affect human and environmental health. Several studies have linked insecticide use with a degradation of air, soil, and water quality. Those who support GM crops believe consuming crops that contain residual amounts of insecticide is more harmful than consuming crops that have been modified. Although crops containing BT genes have the potential to reduce the amount of insecticide used on crops, some studies have produced conflicting results with regards to whether or not a reduction has actually occurred.

GM technology supporters believe that some social issues, such as malnutrition, can benefit from GM crops. In 2004, scientists successfully completed a trial harvest of "golden rice," which was genetically engineered to produce beta-carotene, a precursor of vitamin A. Scientists have suggested that golden rice could be an effective method of alleviating vitamin A deficiency. Such deficiency can cause vision loss, impaired immune functions, and birth defects. A study

published in *The American Journal of Clinical Nutrition* found that golden rice was more effective than spinach, and just as effective as pure beta-carotene in oil, in providing vitamin A to children. Currently, golden rice is produced in the Philippines in an effort to alleviate malnutrition.

Although insecticide-resistant crops may offer potential in reducing insecticide applications, opponents are concerned with the negative impacts associated with planting BT crops. As insects are exposed to BT crops, some insect populations that survive exposure could develop a resistance to BT toxin over time. Subsequent generations of such insects could result in populations of BT-resistant insects that are no longer negatively affected by BT toxin.

Opponents believe introducing GM crops into the environment will cause irreparable harm to the natural diversity of the ecosystem through unwanted gene transfer. Recent studies have observed that some HT crops have affected neighboring nonresistant plants, that now express the genes for herbicide tolerance. Unwanted gene transfer for herbicide tolerance can create "superweeds," that are resistant to traditional herbicides. The resistance could result in the application of more herbicides than originally anticipated.

The abundance of GM crop ingredients found in the U.S. food supply has raised concerns over whether or not foods containing such ingredients should be labeled. Proponents of labeling argue that consumers have a right to know whether or not their food has been modified. Some proponents cite personal or religious concerns about consuming products that may have ingredients containing DNA from a different organism. Labeling opponents state that adding a label to all products containing GM ingredients would make a product appear to be harmful or different from products without GM ingredients. Opponents also say that adding labels would be cumbersome for small businesses.

Both proponents and opponents of GM crops state that scientific evidence bolsters their claims with respect to the safety of consuming GM crops. There are currently no studies that confirm GM crops are unsafe for human consumption. Since GM crop ingredients have only been integrated into the food chain for a short period of time, long-term studies on human health and environmental consequences do not exist. At this time, scientists hope to engage in long-term research to examine whether or not GM crops can cause health problems.

GM CROPS IN WISCONSIN

Wisconsin currently grows GM corn and soybeans. Since 2000, the percentage of planted GM crops in Wisconsin has grown substantially (see Table 1). According to the USDA, 86% of all corn planted in Wisconsin is GM. Wisconsin's GM corn profile is composed of insect-resistant (10%), herbicide-tolerant (23%), and stacked gene (53%) crop varieties. In 2012, 92% of all soybeans planted in Wisconsin were genetically modified. That figure is up from 51% in 2000.

Table 1: Genetically Engineered Wisconsin Crop Varieties, 2000 and 2012

Modification Type	2000	2012
	Percent of all corn planted	
Insect-resistant (BT) corn . . .	13	10
Herbicide-resistant corn	4	23
Stacked-gene corn	1	53
All GM corn varieties	18	86
	Percent of all soybeans planted	
Herbicide-tolerant soybeans . .	51	92

Wisconsin's GM crop profile is similar to the overall profile of corn and soybeans in the United States. For 2012, 88% of corn, 93% of soybeans, and 94% of cotton planted in the United States was genetically modified (see Table 2). Scientists suggest that the next several decades could exhibit a dramatic change in the United States. GM crop profile. Some predict that crops modified to produce vaccines, additional nutrients, or pharmaceuti-

cals could one day comprise a sizable portion of the total GM crop production in the U.S.

Table 2: Genetically Engineered U.S. Crop Varieties, 2000 and 2012

Modification Type	2000	2012
	Percent of all corn planted	
Insect-resistant (BT) corn	18	15
Herbicide-resistant corn	6	21
Stacked-gene corn	1	52
All GM corn varieties	25	88
	Percent of all soybeans planted	
Herbicide-tolerant soybeans	54	93
	Percent of upland cotton planted	
Insect-resistant (BT) cotton	15	14
Herbicide-tolerant cotton	26	17
Stacked-gene cotton	20	63
All GM upland cotton varieties	61	94

CURRENT LAW

Section 146.60 of the Wisconsin Statutes governs the release of certain GM organisms into the environment. This section was created by 1989 Wisconsin Act 15. It requires a notification to the state at least seven days prior to the release of certain GM organisms into the environment. If a person fails to notify the state, they will be required to pay up to $25,000 in penalties and potentially serve up to one year in jail. This section was amended by 1997 Wisconsin Act 283, which provided up to a two-year prison term for subsequent notification violations. In 2001, Wisconsin Act 239 further amended the financial and imprisonment penalties for subsequent violations.

Federal law gives regulatory jurisdiction over GM products to three agencies: the Food and Drug Administration (FDA), the USDA Animal and Plant Health Inspection Service (APHIS), and the Environmental Protection Agency (EPA). Federal policy over GM product safety is determined by the properties of the product, such as chemical composition, rather than the way it was produced.

OTHER STATE LAWS

Several states have laws and regulations in place that prevent producers from labeling genetically engineered products as organic. However, the state of Maine allows foods containing less than 1% of genetically engineered ingredients to be labeled as GM ingredient free.

Other states have laws that address the sale and labeling of genetically engineered seeds. Currently, two states (Vermont and Virginia) have laws that require labels for any genetically engineered seeds.

According to Lexis, 16 state legislatures currently have introduced bills that, if passed, would require labels on any food product that contains ingredients derived from GM crops. Out of those states, Massachusetts and Rhode Island have put their respective GM labeling bills on hold for further study. Such legislation is strongly supported by consumer advocacy groups and organic farmers. Opponents of labeling legislation include many agricultural biotech companies, some farmers, and scientists. Currently, federal regulations do not require foods containing GM products to be labeled. However, crop producers and manufacturers may voluntarily label their products as such.

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