In the past several decades, numerous advances have been made to allow geneticists to genetically engineer specific traits in organisms. Many of these advances have been controversial, especially for food sources that have been genetically modified. The public appearance is that people stand on polar opposite sides, either fully backing the technology and its applications or adamantly fighting its use, the latter often appearing more humane and the former completely profit-driven. However, GM crops should not be accepted or rejected in totality; GM varieties can improve crop yields, nutritional value, and reduce environmental risks. One must evaluate the value of GM crops on a case-by-case basis by examining the potential benefits and concerns of a GM crop.

A recent addition to the list of GM crops allowed in the U.S. is Roundup Ready Alfalfa (RR Alfalfa), a genetically modified variety of alfalfa developed in 2005 by Forage Genetics using a gene construct owned by Monsanto. In January of 2011, the USDA deregulated the production of RR Alfalfa to allow unrestricted commercial sales across the U.S. for the sake of farmer freedom and based on their evaluation of the environmental impact RR alfalfa. Since then, the Center for Food Safety and others filed lawsuits against the 2011 decision.

Alfalfa is not a commonly known plant in the vocabulary of the average person primarily because it is only consumed by grazing animals—dairy cows, beef cattle, sheep, and horses. Also known as lucerne, alfalfa can be harvested up to five times a year for several years to be made into alfalfa hay, which is then shipped to farms. Like other crops, alfalfa has been selectively bred for desirable traits to increase yields in a variety of different environmental conditions.

One of the most constant challenges alfalfa growers face is effective weed control. The dairy and horse industry require high quality alfalfa, free of weeds, for their livestock. Most weeds are low quality in comparison to alfalfa; they have little nutritional value, are unpalatable, and are sometimes noxious or poisonous to animals. Farmers control weeds with traditional herbicides, but often have to use several different herbicides in order to retain effective weed control for their fields. The herbicide “cocktail” varies depending on the weeds present in a farmer’s field and often contains environmentally toxic herbicide formulations; one such herbicide is Velpar, which was detected in drinking water in the Central Valley of California. A more effective and safe weed control strategy is needed for alfalfa farmers.

In 1970, an organic molecule was discovered to be an effective broad-range herbicide, able to control several different weeds. This molecule is called glyphosate. It interferes with the EPSPS enzyme in the shikimate pathway, which is involved in the production of aromatic amino acids necessary for plant growth. This pathway is common among plants; glyphosate is toxic to any plant that has this enzyme, and therefore affects a variety of plants. Small doses regulate growth; large doses kill the plant. Glyphosate is also able to control some weeds—such as dodder, nutsedge, and quackgrass—that are not controlled well by other herbicides. However, there are at least eight common weeds that are less sensitive to
Glyphosate, but can still be controlled by the herbicide if treated when the weeds are young.\(^4\)

Glyphosate is toxic to non-GM alfalfa; in fact it is sometimes used to remove alfalfa fields when farmers wish to plant a different crop.\(^5\) The genetically modified variety of alfalfa that was developed by Forage Genetics has a single bacterial gene inserted into the alfalfa DNA that codes for a C4-EPSPS enzyme instead of EPSPS enzyme.\(^4\) C4-EPSPS is similar to the naturally occurring enzyme in both structure and function, except that it is unaffected by glyphosate. In plants with the C4-EPSPS enzyme, the shikimate pathway can produce the amino acids necessary for plant growth and survival even in the presence of glyphosate.\(^4\)

This genetic modification offers improved weed control strategies for farmers; instead of having to use several different herbicides with varying levels of environmental impact, farmers can use one to two herbicides on their fields: glyphosate, sold as the active ingredient in Roundup herbicide, and perhaps another herbicide to control a weed that is less sensitive to glyphosate.\(^2\)

Glyphosate is also unique from many other herbicides in its relatively short persistence in soils and in water. It is moderately persistent in soil but has a low tendency to run-off; its half-life in soil ranges from 3 to 130 days.\(^6\)

Because mammals do not synthesize their own aromatic amino acids, they have neither a shikimate pathway nor an EPSPS enzyme.\(^4\) Glyphosate has a low toxicity to humans. It should not be ingested, and the eyes should be protected when it is used.\(^7\) Glyphosate does not cause mutations in DNA, tumors, or problems with reproduction.\(^7\) It is a relatively safe herbicide and does not pose a safety concern to humans.\(^7\)

However, there are concerns about RR alfalfa. The most pressing concerns are the possibilities of gene flow, weed shifts, and weed resistance.\(^2\) Gene flow occurs when bees carry GM-alfalfa pollen to non-GM alfalfa on other fields and results in the reduced genetic purity of that breed. When alfalfa is grown for animal fodder, it is normally

To summarize, Roundup Ready alfalfa is resistant to glyphosate, the active ingredient in Roundup, such that an RR alfalfa plot can be treated with Roundup to control a broad range of weeds without harming the alfalfa crop.\(^2\) This results in higher quality alfalfa hay for livestock. A majority of farmers who grow RR alfalfa have noted better weed control and simplicity of weed management with the genetically modified crop.\(^4\)
harvested before it has a chance to be pollinated. Gene flow is an issue only around seed plots, small fields where seed companies produce seed to sell to farmers. Alfalfa seed is grown on less than 100,000 acres in the U.S. Alfalfa seed growing companies are required to plant their seed plots a certain distance from the nearest GM alfalfa field in order to minimize gene flow. 

The modified C4-EPSPS gene will not flow from GM alfalfa to weeds, but some weeds do develop Roundup resistance, such as ryegrass and horseweed. These are called superweeds—they are not affected by Roundup but can still be controlled by other herbicides. Weed shifts occur when the density of an uncontrolled weed increases over time. Both of these issues make Roundup less effective and require the use of more herbicides. The best strategy to avoid Roundup resistant weeds and weed shifts is to rotate crops and herbicides applied to a field. 

The potential economic benefit of RR alfalfa is yet to be seen. Because of the high quality alfalfa hay that RR alfalfa can supply, the dairy and horse industries will likely accept the genetically modified crop. Four percent of the U.S. alfalfa yield is exported, 80% of which goes to Japan. Japan, unlike European countries, has readily accepted the use of genetically modified crops as feed for livestock.

In the case of RR alfalfa, there are potential benefits for its use because it allows farmers to take advantage of the effectiveness of glyphosate on a wide range of weeds and its relatively low toxicity as an herbicide. However, the technology comes with potential problems as well and the initial benefit of using Roundup as an herbicide may dwindle over time as weeds become resistant. Practices such as crop and herbicide rotation are essential strategies for maintaining the value of RR alfalfa. Though the USDA has approved its use in the U.S., it will need to be continually evaluated and studied to ensure its value to society and the environment.

References


Pictures