Lesson 3:
Genetically Modified Plants

The era of genetic engineering in plant agriculture began with the approval of the first genetically modified food crop in 1994. Since then several genetically modified plants have been developed and approved for use. This lesson will examine how these modified plants were developed and how they function.

Developing Genetically Modified Plants

The first step in the development of a genetically modified plant is to find, isolate, and clone the gene or genes that cause the expression of the desired trait in an organism. Often the gene expressing a desired trait has not been identified or located in the DNA of that organism. The process of finding the needed gene can be very difficult. It is easier, however, if researchers have made a genome map of the particular organism, since they will have identified markers that will narrow the search considerably.

The second step involves the selection of a means of genetic transfer. A bacterium or virus can be used as a vector, the vehicle for moving the desired gene into the plant cells. The desired gene and a marker gene are inserted into the bacterium or virus, and the microorganism is placed in contact with the plant cells to be modified. The bacteria or virus infects the cells and transfers the desired gene to the plant cells.

A gene gun can also be used to transfer a desired gene into a plant cell. The desired gene and a marker gene are inserted into plasmid; the plasmid is then placed on the surface of very small (1 mm in diameter), heavy metal pellets. These pellets, usually made of gold, are shot into the plant cells with the use of a small high-pressure gun. High pressure is needed to penetrate the plant's cell wall.

A third method of gene transfer involves the use of chemicals to weaken or dissolve the cell wall. The desired gene could then physically be placed in the cell. After the gene is incorporated, the plant cell is stimulated to repair the cell wall.

The third step in developing genetically modified plants is the selection of the plant cells that incorporate the desired gene into their DNA. The plant cells that contain the desired gene will also contain the marker gene, which is designed to be easily identifiable. These cells will be grown into mature plants through tissue culturing.

How Herbicide-Tolerant Plants Function

Many herbicides kill plants by chemically blocking a metabolic pathway. A metabolic pathway is a series of chemical reactions that are necessary for the survival of a plant. Herbicide-tolerant plants can bypass the blocked portion of the metabolic pathway. This ability comes from genes that produce certain enzymes that provide a different chemical route around the blocked portion. An example of a herbicide-tolerant crop is Roundup Ready™ soybeans from Monsanto. These plants can tolerate glyphosate, the active ingredient in the herbicide. Glyphosate blocks a section of the metabolic pathway, which kills most types of plants. Researchers discovered that a common bacteria found in soil contains a gene that resists glyphosate. They inserted this gene into soybean plants. It produces an enzyme that provides a chemical path around the blocked portion. With this new gene, the soybean plants are not noticeably affected by Roundup™ or any glyphosate herbicide.

How Insect-Resistant Plants Function

A common soil bacterium called *Bacillus thuringiensis (Bt)* was first identified in 1911. Different strains of the bacteria produce a protein that kills some types of insects. When ingested it dissolves the wall of the insect's gut, which causes the insect to be unable to eat and eventually to die. *Bt* was registered as a biopesticide in 1961. However, the pesticide produced from the bacteria had several drawbacks; it was expensive, had to be eaten by insects to work, broke down in sunlight, and was easily washed away by rain. These factors have limited the use of *Bt*-derived pesticides.

Each *Bt* strain kills a specific type of insect. The genes that cause the production of the protein in specific *Bt* strains have been isolated and transferred to several crop plants. For example, Monsanto has developed potatoes, corn, and cotton plants that incorporate *Bt* to protect them against particular insects.

The uses of the *Bt* gene are limited because not all insects are affected by one of the strains of *Bt*. In addition, some people are concerned that insects will become tolerant of the protein produced by the *Bt* gene. If this happens, crops incorporating *Bt* will lose their advantage.

How Disease-Resistant Plants Function

Researchers have developed virus-resistant plants by inserting a small portion of DNA from the virus into the DNA of the plant. This modification gives the plant an immunity to the disease. The Freedom II™ yellow crookneck squash developed by Asgrow is an example of a virus-resistant plant. It resists two types of the mosaic virus.

The development of bacteria- and fungus-resistant plants has not been as easy or as fast as the development of virus-resistant plants. Current research in this area centers on trying to enhance the plant's natural immune response to attacks by bacteria and fungi. Some plants seem able to withstand them better than others. Scientists are trying to find out how these plants work so that they can genetically modify crop plants to have this ability. Bacteria- and fungus-resistant plants are not currently available, nor are they expected to be for several years.

The Effect of Biotechnology on Food Quality and Processing

Biotechnology has been used to enhance food quality and food processing. One of the first genetically engineered plants was the FlavrSavr™ tomato. The tomato was developed by Calgene, a subsidiary of Monsanto, to have a vine-ripened taste and a longer shelf life. Genes were inserted into the tomato plant to delay the softening of the tomato by causing the production of an enzyme that slows the breakdown of pectin in the tomato. Pectin prevents the tomato from getting soft and rotting. Four other companies have gained approval for similar genetically modified tomatoes.

Genetically modified canola and corn plants have also been developed. Both corn and canola plants have been genetically modified to produce grains that are higher in oil content and have a modified oil composition. This means that the levels of saturated and unsaturated oil from these plants have been changed to meet different uses. An example of this type of product is a canola plant from Calgene named Laurical® that produces seeds high in lauric acid. The oil they produce can be used in processing many food products.

Monsanto is working on high-starch potatoes. These potatoes are higher in starch and lower in water content than unmodified potatoes. When the new potatoes are sliced into chips or french fries and deep fried, they will absorb less oil. They will therefore have a lower fat content.

Summary

The genetic engineering of plants has yielded better quality foods and plants that are herbicide tolerant, insect resistant, and disease resistant. The development of these plants involves the location, isolation, cloning, and transferral of the desired genes.

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