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THE IMPACTS OF A Transformation

Genetically Modified Organisms (GMOs)

For millions of years, agrobacterium tumefaciens, a species of soil-dwelling bacteria, has been taking advantage of plant cellular machinery. By putting its bacterial DNA into plant chromosomes, agrobacterium is able to ensure the proliferation of its own population (1). This idea of altering the DNA of one organism to improve another has been used in recent years to genetically modify a number of species including soybeans, tomatoes, grasses, corn and rice.

In the cell of an agrobacterium tumefaciens there is a bacterial chromosome and a TI plasmid, a DNA molecule that replicates independently of chromosomal DNA. DNA housed in this plasmid is copied, and is able to exit the bacterial cell through a channel in the membrane. This transfer DNA then enters a plant cell and moves into the nucleus, integrating itself into the plant chromosome. An array of genetically modified organisms are transformed in much the same way, all resulting in heritable changes brought about by the uptake and integration of introduced DNA (3). For example, to achieve favorable characteristics, one can take DNA from a fish that can survive low temperatures and insert it into a strawberry to make it frost resistant. GMOs can also be produced through calcium phosphate precipitation where the selected DNA forms tiny granules when mixed with calcium phosphate. The target cell, or cell obtaining the foreign DNA, then uses endocytosis to uptake the granules and release the DNA into its nuclei (1). Additionally, viruses, bacteria and liposomes can be used as DNA carriers to transfer DNA between organisms and create a GMO.

RISKS

The risks associated with a GM crop depend on complex interactions among the specific genetic modification, the organism's natural history, and the properties of the ecosystem in which it is released (2). Also, the implementation of a genetic modification that allows for herbicide resistance can reduce biodiversity. Additionally, if genes are moved into nonagricultural locations, the fitness of certain weedy species, for example, could eliminate endangered species in that area (4). Synthesizing rice production so that it is fortified with vitamin A or other proteins could also be a detriment to a local ecosystem. If the protein is incompatible with other organisms in the ecosystem, it can result in their decline. Also, increases in nitrogen-fixating organisms can lead to a degradation in human health and also contribute to a loss in biodiversity.

GMOs also tend to be incompatible with organic production. While organic processes are based on the full disclosure of traceability, genetic engineering is secretive. These actions have allowed GMOs to avoid inquiry and has resulted in the absence of labels in the US food supply. While GMOs make up about 80% of soybean, cotton, and corn growth in the US, the public has limited knowledge regarding GMOs. In fact, only 10% of people surveyed in the US and Japan claimed to have what they deemed sufficient knowledge on GMO and GM foods (6).

An inverse correlation has been found with GMOs and the decline in the populations of Monarch butterflies, black swallowtails, lacewings, and caddisflies, and there may be a relationship between genetic engineering and colony collapse in honeybees (1). Soil ecosystems have declined due to the persistence of toxic Bt corn residues.

BENEFITS

By employing GMO technology, crops can be engineered to resist insects and thus reduce the need for insecticides. For example, if a toxin from a soil particle is inserted into a plant crop, then that plant crop can produce specific toxins that will eliminate the larvae population of their targeted pest. Genetic modification can also reduce the need for broad-spectrum pesticides that kill non-target organisms. If pesticide resistant crops are genetically engineered, then the pesticides previously used are eliminated and can no longer harm other organisms (1).

It is also possible to modify organisms in order to increase nutritional content. Omega-3 fatty acids, a boost to heart health, now can be incorporated into genetically modified plants and meats. This concentration of nutrition in plants has lead to the product termed "golden rice" which contains beta-carotene, vitamin A, and iron. With risks of maternal anemia and blindness in developing countries due to vitamin deficiencies, genetically modified organisms can feed growing populations and prevent disease (4).

Bt cotton, a widely used GMO, contains genes from Bacillus thuringiensis that make it resistant to the cotton bollworm complex, or mass damage to cotton through the larvae of the bollworm (1). In India, Bt cotton was shown to have a 24% increase in cotton yield per acre through reduced pest damage and a 50% gain in cotton profit among smallholders (3). Thus, this inbuilt insect resistance led to productivity gains, savings on chemical pest controls, and a reduced number of acute pesticide poisonings (1).

Looking Forward

In the future, GMOs may play an even larger role in our society. For example, a GM apple could lead to the vaccination of children against a virus that is a cause of pneumonia (1). Tomatoes and broccoli bursting with cancer-fighting chemicals and bananas that provide vaccines could be on the horizon (1). Inserted genes in Atlantic salmon could allow them to grow in half the normal amount of time and thus reach the market sooner (2).

Whether these new advances in research are positive or negative, there is much international dialogue on the issue. The potential widespread impacts of a GM crop depends on its ecological function and natural history with the agroecosystem and ecosystems within which it is embedded (4). GM crops may be the best means of agricultural intensification currently, yet a truly comprehensive risk assessment is crucial to understanding any negative implications.

Figure 1: Fruits may be potential targets of genetic manipiulation. ***Photo credit to Wikipedia.***

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