Bioengineering of Agriculture Products: Feeding the World or Frankenfoods and Superweeds?

An Informational Report

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Introduction

The transfer of genes from one species to another is perhaps the most important component of the technical revolution that is changing our world. As applied to agriculture, it is fast becoming the most controversial as well. Genetic modification is accomplished by isolating a gene from a plant or animal, and splicing it onto the DNA of another plant or animal to give it new characteristics. Previously, selective breeding did not go beyond the limits of managed cross-pollination, hybridization and mating. It was carried out within established species barriers; corn with corn, pigs with pigs and so on.

The most compelling reason for development of genetically engineered (GE) food is the precarious future of the poor undeveloped countries as the world population increases. It is projected that demand for grain, for both human consumption and animal feed, will increase by nearly 50% by 2020.

In fact development, pollution, erosion, and a shrinking supply of water for irrigation are leading to an alarming decrease in arable land. In many undeveloped areas much of the agricultural production is lost to rot before it can reach the needy populations.

Concerns about genetic engineering include the fear that eating such foods may cause allergic reactions, that herbicide-resistant crops may pollinate weeds making them superweeds and the plants with properties that kill predatory insects will spread their pollen to other plants which are the food of untargeted insect species. There is also concern that totally unforeseen environmental effects may occur. The opposition to what opponents call "Frankenfoods" began in Europe and lately a well-supported campaign against genetic engineering has formed in the U.S. and adherents have been demonstrating and lobbying vigorously.

What Has Happened

Genetically engineered annual crops made their commercial debut in the mid 1990s. Today, a mere three years after the first large-scale harvest, genetically engineered crops cover one-fourth of the U.S. annual cropland (more than 90 million acres according to 1999 industry estimates). The Department of Agriculture (USDA) has approved fifty genetically engineered crop plants, however some are not yet being grown in large numbers. The genetically engineered crops presently grown in the U.S. are corn, soybeans, potatoes, tomatoes, melons and beets. Others, such as wheat, cucumbers, strawberries and sugarcane, are still being tested. Genetically engineered crops have been marketed to farmers and agri-business not consumers.

In the past decade, about 130 tests of genetically modified trees have gotten the go-ahead from the Agriculture Department's Animal and Plant Health Inspection Service (APHIS) which has primary responsibility for regulating bioengineered trees in this country. The first application for permission to grow large commercial tracts of new trees is expected to come around 2005. APHIS approved field trials of more than 50 genetically altered variants of apples, grapefruits, pears, persimmons, plums and walnuts in 18 states.

The Department of Agriculture divides farms into three economic classes: small with annual sales of $1,000 to $9,999; medium, with sales of $10,000 to $99,000 and large, with sales of $100,000 to more than $1 million.

The Issues

Genetically engineered ingredients are already present in everything from infant formula to corn muffin mix, they are more widely used in food products than most people realize. There is no evidence that the genetically engineered food now on the market is unsafe to eat. Two of the biggest issues in the ongoing debate over genetically engineered foods are: should they be labeled in the U.S. as required in a number of European countries, and what are the long term environmental and health effects?

Consumer groups are adamant about their right to know what they are eating. Trade issues are equally contentious. Countries that spurn genetically engineered products demand that there be no mixing of non-genetically engineered products and what they like to call "Frankenfoods". The Food and Drug Administration (FDA) says that the products have been thoroughly tested, are perfectly safe and do not need special identification. A Grocery Manufacturers of America spokesman says that 60% of consumers would consider any mandatory biotech label as a warning that the product is unsafe.

Benefits

With proper safeguards, genetic engineering offers the possibility of foods that benefit consumers. Examples are breads and oatmeal that help lower cholesterol or vegetables packed with cancer fighting ingredients. Potatoes could be genetically engineered to contain a vaccine against Norwalk virus, a major cause of infectious diarrhea. Canadian scientists have already announced that they have engineered "Enviropig," a porker with replicated mouse genes which produces manure with less phosphorus (a key pollutant in farm runoff). Some scientists are altering corn to produce pharmaceuticals, and bananas to provide vaccines.

Another genetic engineering project is aimed at controlling striga, a weed that parasitizes the roots of African corn plants. Scientists hope to identify the genes exuding chemicals that attract the striga and turn them off. A sweet potato has been produced that is protected against deadly mosaic virus. (Sweet potatoes are a staple diet of both Kenyans and Mexicans.) A virus-resistant transgenic papaya, which increases yields, has recently been introduced.

The most far-reaching new product is a modified rice strain called "golden rice" containing beta-carotene to protect undernourished children from illness and blindness. It is an example of a finished product targeted at the problem of world hunger. Patent rights to processes used in the development of "golden rice" have delayed approval of distribution rights. The new rice is the work of European university scientists. Several of the owners of the patents to the genes used in creating the rice have agreed to waive their right to patents and to give the rice to poor farmers in the third world in exchange for commercial rights in the U.S. and other affluent world markets.

Ecological Risks

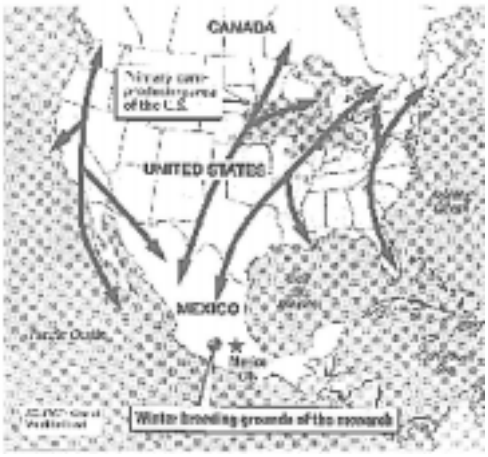
The giant biotechnology companies which have developed the genetically engineered crops claim that they will give us better and more nutritious food, reduce our use of herbicides and save the world from hunger. To date, world-hunger issues have not been the driving force in the marketing of current technology. Many of the genetically engineered crops already on the market, or in the pipeline, are modified to be used alongside herbicides, not instead of them. Genetically engineered crops with built in herbicide resis-

tance make it possible to spray herbicides directly over crop plants. Products introduced by commercial companies have been largely aimed at benefiting crop plants.

Probably the most used genetically altered process is the insertion of a pesticide into the genes of corn, cotton, potatoes and other crops. This makes it unnecessary to spray pesticides for major predators of these crops. The pesticide is Bacillus Thuringiensis (Bt), a soil bacterium that produces toxins which attacks the digestive system of caterpillars. The Bt toxin is deactivated in an acidic digestive system. Most animals, including mammals, have acidic digestive systems. Caterpillars do not. Organic farmers are furious at the use of the Bt crops. It is one of the few natural pesticides used, and it is more benign than many synthetic pesticides. Fairfax County uses it in their Gypsy moth spraying program.

Several laboratory experiments and a recent modified field study have raised fears that Bt crops would be damaging to the Monarch Butterfly and their larvae. But, according to the USDA's, *Frequently Asked Questions*, page 5 states "*the effect of corn pollen on Monarchs is likely small because corn pollen is heavy and so is not blown far, and milkweed, the Monarch's primary-host, is controlled around corn fields.*" Users of Bt also worry that as it comes into use, a resistant strain of insects will develop and the insecticide will lose its effectiveness. To prevent this, growers are urged to plant Bt free plots next to protected fields so that susceptible insects will prosper and interbreed with the new strain.

Monarch Butterfly Migration Routes



Bt corn has been planted since 1996, and now accounts for about one-third of all corn planting. The Bt in the corn protects against corn borers, which cause an estimated $1 billion in yearly crop damage. Much of the nations' corn is grown in the Midwest, which is on the migration path of monarchs. The Monarch Butterflies lay their eggs on the underside of the leaves of milkweed plants, which commonly grow in or near cornfields. Pollen from the genetically engineered corn could land on the milkweed when blown by the winds. Pollen of any kind in the diet of monarch larvae can be deadly. At the time of year that the Butterflies migrate the corn is not pollinating so it is not a threat to them.

Protection of beneficial and other non-targeted insects is a vital concern. Some European scientists have noted that genetically engineered crops could harm ladybugs and lacewings, two other beneficial insects. Meanwhile, others found in a lab study, when honeybees were fed concentrated solutions of proteins from genetically engineered rapeseed, they had trouble learning to distinguish among the smell of flowers and some died sooner than unexposed bees. These laboratory studies showed that these harmful effects

might be manifested in a field environment. But, to date no real in-field tests have been conducted to satisfactorily prove or disprove any of the laboratory based claims.

Other Risks

The technique used by genetic engineers is not precise. Where a gene is inserted and how many copies are inserted cannot be controlled. At Germany's first large scale experiment on genetically altered petunias, many more turned white than expected and when temperatures cooled, they turned variegated shades. This cutting and splicing of genes and how a gene behaves in a test tube does not tell us how the gene operates in its natural context or how it might behave in another species. The transferred gene contains instructions for making proteins. Some, those in peanuts, for example, are well known for causing allergic reactions.

Approximately thirty percent of cow herds in the United States are given a genetically engineered growth hormone named recombinant bovine somatotropin (rBST) which stimulates milk production. This hormone is produced by genetically engineered bacteria and is accompanied by a long list of possible side effects. The Canadian Government has refused to license it for use in its country because it increases udder infections by twenty-five percent and lameness by fifty percent.

One of the most contentious issues of genetic modification that has elicited much concern is "terminator" technology, so called because it makes the plants produce sterile seeds or "traitor" seeds, which are activated only by a proprietary chemical. Although this is not an environmental worry, because the sterile organism cannot spread into the ecosystem, it is a social and economic problem. Poor farmers would be unable to produce their own seeds for their next crops in poverty stricken economies. This technology was developed as a way for biotech companies to ensure that only paying customers can take advantage of their research investments. The USDA and a private company holds the patents on terminator technology.

> Large Farms have distinct advantages. They usually can produce more for less, and since government commodity programs and disaster payments are based on production, large farms get a bigger slice of the subsidy pie.

Organic Agriculture

Driven by consumer demand and growing dissatisfaction with conventional farming practices, organic agriculture is thriving worldwide. More than 18 million acres are now devoted to certified organic agriculture in 130 nations, according to a recent U.N. survey. Consumers have become wary of cows or chickens whose growth has been enhanced by hormones and of produce that may have herbicide or pesticide residues. As a result, the world market for organic food grew to an estimated $22 billion last year. Some specialists expect the American market to expand rapidly in the next five years, possibly as much as $100 billion.

Organic farmers are concerned about genetically engineered crops grown widely in the United States. They believe it may be impossible to prevent their crops from being contaminated by "genetic pollution" from the genetically engineered crops pollen. Even with an unplanted perimeter (about 400 yards are recommended) around fields sown with genetically engineered crops, it might be possible for cross-

pollination or hybridization with related crops and weeds. Pollen can travel as far as three and a half miles when carried by bees and birds or blown by the wind. Genetic engineering of plants or animals is not considered organic farming.

The Role of the Federal Government

Three agencies are primarily responsible for regulating biotechnology in the United States: the Department of Agriculture (USDA), the Environment Protection Agency (EPA) and the Food and Drug Administration (FDA). FDA policy is based upon existing food law and requires that genetically engineered foods meet the same rigorous safety standards as is required of all other foods. The biotechnology policy of the FDA treats substances, intentionally added to food through genetic engineering, as food additives provided that they are significantly different in structure, function, or amount from substances currently found in food.

Many of the food crops currently being developed using biotechnology do not contain substances which are significantly different from those already in the diet and thus do not require pre-market approval. Consistent with its 1992 policy, FDA expects developers to consult with the Agency on safety and regulatory questions. Several USDA agencies are involved in monitoring the use of biotechnology for agriculture. They include the following:

- The Animal and Plant Health Inspection Service (APHIS) regulates the movement, importation and field testing of Genetically Engineered Organisms (GEOs) through permitting and notification procedures. In addition APHIS Veterinary Biologics inspects biologics and production establishments and licenses genetically engineered products.
- The Food Safety Inspection Service (FSIS) has responsibility for the safe use of engineered domestic livestock, poultry and products derived from them.
- The Agriculture Research Service (ARS) conducts in-house research on Genetically Engineered Organisms.
- The Economic Research Service (ERS) conducts research on the economic impact of Genetically Engineered Organisms.
- The Foreign Agriculture Service (FAS) monitors foreign regulations and restrictions of Genetically Engineered Organisms.
- The Cooperative State Research, Education and Extension Services (CSREES) administers the biotechnology risk assessment program as well as research programs in gene mapping, sequencing and biotechnology applications.
- The Agricultural Marketing Service (AMS) facilitates the strategic marketing of agricultural products including seed regulatory and testing services and granting of intellectual property rights for certain plant varieties.
- The Grain Inspection, Packers and Stockyard Administration (GIPSA), which facilitates grain and oilseed marketing by providing quality standards and inspection services, will address the market's need for standardization and validation of testing methods used commercially for determining whether or not products were derived from biotechnology through its reference laboratory.
- The EPA, under the authority of the Toxic Substances Control Act (TSCA) Biotechnol-

ogy Program regulates microorganisms intended for commercial use which contains or expresses new combinations of traits. This includes "intergenetic microorganisms" formed by deliberate combinations of genetic material from different taxonomic genera.

• A part of the Department of Health and Human Services, FDA regulates food and feed derived from new plant varieties under the authority of the Federal Food, Drug, and Cosmetic Act.

The regulatory framework is fragmented and largely run on the honor system. No one agency takes responsibility for the entire product. The government's logic is to rely on the biotech firms to provide summaries of their studies not the complete data. Safety testing is restricted to a fairly straightforward set of chemical comparisons between the genetically engineered crop and its non-modified equivalent. For example, are vitamin C levels similar? Are the crop's processing characteristics the same? Is the fatty-acid profile of the food the same? If the answers to such questions are yes, then a new food is likely to get the go-ahead.

The Senate Agricultural Committee has quietly approved a measure that could nullify many state food safety regulations. Under the National Uniformity for Food Act of 2000, state and local governments will no longer be able to set safety warnings for products sold in their jurisdictions if the warnings exceed those required by the federal government. A coalition of food and supplement industry groups, led by the Grocery Manufactures of America, played a key role in formulating the bill. It supersedes California's Proposition 65, a 1986 voter initiative requiring warning labels to disclose whether products contain chemicals that cause cancer or birth defects.

On May 3, 2000, the Clinton administration announced plans to reinforce the Strength and Transparency of Science-Based Regulation. The Council on Environmental Quality (CEQ) and The Office of Science and Technology Policy (OSTP) will conduct a six month interagency assessment of Federal environmental regulations pertaining to agricultural biotechnology and, if appropriate, make recommendations to improve them. The FDA will develop guidelines for voluntary efforts to label food products under their authority as containing or not containing bioengineered ingredients in a truthful and straightforward manner, consistent with the requirements of the Federal Food, Drug and Cosmetic Act. The USDA will work with farmers and industry to facilitate the creation of reliable testing procedures and quality assurance programs to differentiate non-bioengineered commodities to better meet the needs of the market.

The number of small farms rose to 962,966 in 1997, an increase of 56,449 since 1992. The number of large farms climbed to 345,988, a 31,111 increase. But the number of medium-sized farms dropped to 602,905, a loss of 103,001 farms.

The Fallout

In the past year the Gerber and Heinz companies have said they are planning to rid their baby food of genetically engineered ingredients. Gerber is looking into possible labeling options. McDonald's has pledged not to use Bt potatoes in their products and Frito-Lay will no longer use Bt corn. Although all four companies believe the products are perfectly safe, they are afraid of losing market shares as consumers

begin to become concerned. Protestors have targeted several other companies, Kellogg and Campbell among them. To date, no announcements of any changes have been made in any of the foods they manufacture.

What's in the Pipeline?

If research continues at its present rate, trees in western Canada soon will bear apples whose crispy white flesh won't turn brown even hours after being cut. In the next decade there could be peaches engineered to ripen more slowly and deliciously after harvest and cherries in a variety of fashionable colors.

Scientists are working on creating sterile trees which can devote their energy toward growth, and will increase the concentration of cellulose, the ingredient of prime commercial value in trees. Some trees may be able to gobble up enough carbon dioxide to help slow global warming. Still others may be capable of being digested into pulp without the tons of toxic chemicals that today poison the rivers around paper mills.

A "forest" of sterile trees may have unknown ecological impacts. Will the genetically altered trees cause more allergies in people not usually bothered by tree pollen? What will happen to the birds, insects and other wildlife that depend on tree pollen, nectar and seeds for their daily food?

The restrictions on outdoor testing of genetically engineered trees are virtually identical to those already in place for annual crops. In most cases, growers must simply sign a statement promising they will follow general guidelines to protect the environment.

Some researchers are working to genetically modify Atlantic salmon to use more of its own growth hormone so that it can grow 400 to 600 percent faster. Others are working on bigger rainbow trout. Still others are working on "low mow" grasses and manipulating the gene to give us roses, gerber daises, lilies, chrysanthemums and carnations with the color blue. So while scientists work to perfect the maintenance-free yard, gardeners will have to wait to see if the grass is really greener on the genetically altered side. It is not known whether such products will become popular with consumers. At the very least, they'll likely fuel the debate over genetic engineering now and for years to come.

The Uncertain Future

Fierce antipathy toward agricultural bioengineering has grown up in Western Europe. The proponents embrace their cause with an almost religious fervor. Relatively small and well-subsidized farms plus Britain's recent trauma involving mad cow disease, created a dim view towards agricultural bioengineering. Laws have been passed banning all bioengineered products. The sentiment has been spreading to other countries in the developed world including the U.S., Japan and Brazil.

The effects of this hostile climate can already be seen in the biotechnology industry. Two large prominent companies have abandoned their involvement in the industry. There are parts of the world where hunger is a real threat and are eager for genetically modified crops. Unfortunately they are also the countries without money to support this new industry. What will this mean for biotech agriculture? Will industry reduce its investment or step back from its prominent role, perhaps using grants and marketing agreements to assume a background position?

Many people are concerned about the tremendous rush to market with genetically altered seeds and

the speed with which these products have entered our lives. The bioengineering companies gave little or no attention to the possible reaction of the American consumers. The government regulating agencies did not have the time and funds to prepare themselves to evaluate the products of an entirely new and untried science. Will government overseers and peer reviewers bring more public confidence in its health and environmental security?

It appears that there may be an important change on the way. While most of the products marketed to date are innovations that make farming easier, the next generation will be devoted to products with consumer benefits, i.e. foods which lower cholesterol, reduce cancer risk and are more nutritious. Will science be able to eliminate all the risks and be able to address all the fears of this new technology? Time will tell. We may find ourselves in a better position to measure the risks against the benefits of each new "wonder-food" that comes along.

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