Novel Crops and Other Transgenics: How Green Are They?

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As biotechnology develops, we could see the advent of biological pollution, which could be more dangerous than nuclear or chemical pollution.[1]

Monsanto's agricultural biotechnology provides improvements in quality and yield of crops, and benefits the environment where crops are grown.[2]

Agricultural and environmental applications of modern biotechnology have spurred considerable controversy about their environmental risks and potential to alter the environmental impacts of other technologies and practices, such as pesticide use. The range of biotechnology products under development is expanding rapidly, and thus the potential for controversy over the environmental effects of biotechnology products is also increasing.

The purpose of this paper is to examine environmental issues associated with novel genetically engineered organisms being developed for agricultural, pharmaceutical, and environmental applications. First, I will consider the purposes of these novel biotechnology products and whether environmentalists view these products as environmentally beneficial. Second, I will consider the environmental risks of these novel biotechnology products. Third, I will examine one novel regulatory approach to managing environmental impacts of one category of biotechnology products.

[1]Martin Khor. 1994. Why we need a Biosafety Protocol urgently. Third World Resurgence 48:20.

[2]Monsanto press release. Monsanto receives final regulatory approval for commercialization of insect-protected cotton. October 31, 1995.

ARE NOVEL BIOTECHNOLOGY PRODUCTS GOOD FOR THE ENVIRONMENT?

Biotechnology products frequently are touted as environmentally beneficial. Even in the face of such claims, however, it is unclear to many environmentalists whether biotechnology products will be good for the environment. In part, this is simply because of the increasingly varied nature of biotechnology products, which range from industrial chemicals to transgenic animals. It is unreasonable to expect that as a class, biotechnology products will be "good" or "bad" for the environment. But even individual biotechnology products or types of biotechnology products face skepticism from the environmental community, for at least two reasons.

The first reason is that the environmental community has grown wary of environmental claims in general. As public support for environmental protection has grown, corporate environmental claims for products have become more common. Unfortunately, these claims are not always legitimate. Plastic supermarket bags, for example, sometimes are touted as "ecological," even though the bags are not made from recycled materials and customers frequently dispose of the bags after one use. The practice of telling consumers that particular products are good for the environment, even when their environmental benefits are dubious, has become so common that the environmental community has given this practice a special name: greenwashing. As greenwashing has become common, so has legitimate skepticism of environmental claims — including claims for biotechnology products.

Second, skepticism about environmental claims for novel biotechnology products is also based on past experience with hype concerning the potential of biotechnology. In the past, for example, biotechnology's promoters have promised that fertilizers will become unnecessary as crops are engineered to fix their own nitrogen, and that pesticides will become obsolete as crops are engineered to resist insects and other pests. Those unrealistic claims have spurred general caution about environmental promises for biotechnology products.

As a specific illustration of the environmental community's response to biotechnology products, consider bioremediation, a technology that has been promoted heavily as one way in which biotechnology will aid environmental protection. Most environmentalists support the concept of bioremediation — harnessing natural processes to degrade hazardous chemicals. Nevertheless, the environmental community has not rushed to embrace bioremediation as the solution to problems with hazardous wastes.

In part, this response is based on the potential of environmental "snake oil" to be disguised as a legitimate bioremediation product. Following the oil spill from the tanker Mega Borg off the coast of Texas in 1990, for example, one Texas company promoted heavily the success of its bioremediation product — bacteria that supposedly "eat" oil on the surface of the ocean. According to a report published by the Texas General Land Office, these bacteria largely dissipated an oil slick from the Mega Borg in just seven hours, with portions of the slick breaking up in just 30 minutes. The speed of this degradation is difficult to believe, especially given that the experimental design had no replication of treatment and control areas, and because the oil in the treatment area simply may have been dispersed by wind and water. The relatively low cost of such bioremediation techniques makes them attractive to government agencies and companies that must remediate waste, but also signals caution to many environmentalists. Reliance on inexpensive but unproved bioremediation products could cause considerable environmental harm if the result is that more efficacious cleanup methods are not used.

Not just skepticism, however, has caused bioremediation's relatively low profile in the environmental community. Many environmentalists are now focused on pollution prevention rather than remediation of wastes. Changing industrial processes to minimize the amount of waste produced is regarded as the best way to end the problems caused by chemical wastes. Over the long-term, biotechnologists may do more for the environment by developing novel enzymes and other tools that allow the redesign of industrial processes, than by developing bioremediation methods.

DO NOVEL BIOTECHNOLOGY PRODUCTS POSE NOVEL RISKS?

As of May 1996, government records indicated that in the United States there had been about 3,500 field tests of genetically engineered plants, 50-100 field-tests of genetically engineered microorganisms, and two field-tests of genetically engineered fish. These numbers continue to grow, involving an ever greater diversity of genetically engineered organisms. I will examine the environmental risks associated with genetically engineered products, as these risks apply to species or taxa that only recently have been genetically engineered.

Crop plants: Within the predominant group of engineered organisms — plants — the range of species being field-tested until recently has been relatively narrow. As of March 1993, about 85 percent of field-tests of genetically engineered crops were of six species: corn, cotton, tomatoes, potatoes, soybeans, and tobacco. However, the diversity of crops being genetically engineered has increased substantially: transgenic varieties of more than 40 different crop plants have now been field-tested in the United States. These include fruits and vegetables such as cranberries, papayas, raspberries, and radicchio; ornamentals and turf plants such as chrysanthemums, gladioli, petunias, and creeping bentgrass; and trees such as poplars, spruce, and sweetgum. Moreover, the range of traits being introduced to crop plants is also increasing. Along with insect, disease, and herbicide resistance — the traits most commonly introduced to crops — a number of crops are now being engineered to produce pharmaceuticals, polymers, and industrial enzymes, and to alter oil, starch, and protein contents.

The prominent ecological risk associated with crop plants is that they will transfer, via pollination, their acquired genes to related wild or weedy plants, or to other cultivated non-transgenic varieties of the same crop. How will these gene transfer risks apply to the wider range of crop varieties now under development?

The answer to this question is not straightforward. Gene transfer to wild or weedy-related plants may pose both lower and higher risks. The primary concern about such gene transfer is that the transferred genes may encode a trait that confers a selective advantage. Populations of wild or weedy plants that acquire the trait may increase to the extent that they become an ecological or agricultural nuisance. Acquired traits for insect, disease, and herbicide resistance — the traits that have long dominated genetic engineering of crop plants — realistically could confer a selective advantage to a wild plant. However, it is difficult to envision many other traits now being engineered into crops, such as production of pharmaceuticals, polymers, and industrial enzymes, and altered oil, starch, and protein content, as conferring a selective advantage to a wild plant. Therefore, transfer of such traits to wild or weedy plants generally should pose low risks.

On the other hand, the wider diversity of plant species now being engineered could increase the likelihood of gene transfer to wild or weedy plants. Concerns about gene transfer by most of our major crops — the traditional focus of genetic engineering efforts — are minimal in the United States. Most of these crops originated in other areas of the world and do not have wild relatives in the United States. Genetic engineers, however, now are focusing increasing attention on plants such as forest trees and ornamentals that have wild populations in the United States. Many of these plants readily can transfer their acquired traits to wild relatives, and thus have the potential to pose significant gene transfer risks.

Gene transfer from transgenic varieties to cultivated non-transgenic varieties of the same crop on average may pose higher risks than in the past. Gene transfer to cultivated, non-transgenic varieties to date has not been a focus of great concern, because most introduced genes are intended for use in food crops and are intended to be safe for consumers. For example, consumers likely would not be exposed to significant health hazards if a small percentage of a corn crop acquired a herbicide-resistance gene from a transgenic corn growing nearby. (One important exception to this generalization would be the transfer of genes encoding substances that are safe for most consumers, but allergenic for a minority of consumers, which would pose a serious risk for the allergic minority.)

In contrast, genes encoding pharmaceuticals or industrial chemicals are not intended to be used in foods, and expression products of such genes could pose health hazards to consumers. Transfer of such genes from transgenic to non-transgenic varieties could contaminate food derived from the non-transgenic varieties, posing health risks to consumers.

Fish: Sharp declines in wild fish stocks and new technologies have created strong economic incentives for aquaculture (fish farming). In the United States, aquaculture production more than doubled between 1984 and 1993, and aquaculture is now the fastest growing segment of agriculture. Worldwide, aquaculture is growing by about 10 percent each year. Farmed shrimp, for example, now are more than 30 percent of the world shrimp supply.

Interest in engineering aquatic organisms for aquaculture is growing rapidly, potentially creating new environmental risks. One United States company, AF Protein of Newton, Mass., has approached the United States Food and Drug Administration for approval to commercialize Atlantic salmon engineered to produce a growth hormone from chinook salmon. According to AF Protein, their transgenic salmon fry grow 400-600 percent faster than their non-engineered kin.

Such transgenic fish arguably pose some of the greatest risks of any type of transgenic organisms. Aquaculture facilities are notoriously leaky. Data from waters off Scotland's Faroe Islands, for example, indicate that as many as 48 percent of the salmon caught by commercial fishermen have escaped from salmon farms. In general, fish escaped from aquaculture facilities are reasonably likely to survive and breed with natural fish populations, because most fish have not been debilitated significantly by domestication. Therefore, transgenic fish readily may transfer their engineered traits to wild fish populations, where these traits might spread via natural selection. Having acquired an advantageous trait, fish then could affect populations of other aquatic organisms — for example, by competing for food. These sorts of ecological effects are of concern particularly because considerable experience with introductions of "exotic" fish from other geographic areas suggests that aquatic ecosystems are highly vulnerable to ecological disruptions.

Invertebrates: Recently, a number of invertebrate species have been engineered for the first time. In 1996, the USDA received the first applications for field tests of transgenic mites and nematodes. In aquaculture, shrimp and mollusks were first reported as transformed. Ecological risks posed by introductions of transgenic invertebrates have only begun to be examined. Those risks especially merit scrutiny because many invertebrates are highly mobile at certain life stages and have extremely high reproductive rates, and because transgenic invertebrates readily may interbreed with wild conspecifics.

Novel regulatory approaches to managing environmental impacts of agricultural biotechnology

Innovative new regulatory approaches may help our society better manage the environmental risks and controversies associated with an expanding universe of biotechnology products. One potentially helpful regulatory tool is conditional registration of pesticides. For some products, conditional registrations may strengthen environmental protection while providing significant advantages for regulators and manufacturers.

In order to market a pesticide in the United States, the substance must be registered by the U.S. Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). In general, a company submits considerable data to the EPA concerning the human health and environmental impacts of their product. Based on these data, the EPA decides whether to register the pesticide. If the EPA chooses to conditionally register a pesticide, the agency continues to require the submission of data over a certain time period after the pesticide is commercialized.

FIFRA was originally amended to allow conditional registrations in order to eliminate a double standard that arose as a result of increased data requirements under the statute. Conditional registrations enabled the EPA to allow manufacturers to start selling a pesticide while working to fill data gaps, as long as the EPA determined that the conditional registration would not increase significantly the risk of any unreasonable adverse effect on the environment.

The EPA's use of conditional registrations took an unprecedented turn in March 1994, when the agency granted a landmark registration to two agrochemical companies — Monsanto Company and Zeneca AG — for the herbicide acetochlor. The EPA conditionally registered acetochlor on the basis of arguments by the herbicide's manufacturers that the availability of acetochlor would greatly reduce overall herbicide use on midwestern corn crops. Amid considerable controversy, the EPA weighed the manufacturer's arguments for environmental benefits against other evidence that acetochlor is carcinogenic and may leach into ground water. Taking an unprecedented step, the EPA registered acetochlor, but established a number of conditions for continuing the registration beyond an initial five year period. Monsanto and Zeneca must document promised decreases in herbicide use and must fund programs to monitor ground water and surface water for acetochlor contamination. If the companies do not meet these conditions, the EPA will cancel the pesticide's registration.

The EPA subsequently issued several conditional registrations involving genetically engineered crops. In May 1995, the agency conditionally registered bromoxynil for use on cotton that was genetically engineered to tolerate this herbicide. This registration was highly controversial because bromoxynil is absorbed through the skin and is a reproductive toxin, thus posing health risks to farm workers. However, bromoxynil's manufacturer argued that use of bromoxynil-tolerant cotton would lead to a decrease in overall use of more hazardous herbicides on cotton. Similar to acetochlor, the EPA conditioned bromoxynil's registration on the requirement that the manufacture substantiate its claims of a net environmental benefit.

Later in 1995 and in 1996, the EPA conditioned registrations of corn and cotton genetically engineered to express insecticidal Bt toxins from bacteria. Preparations of naturally occurring Bt bacteria already are used as a safe insecticide on relatively limited acreage by both conventional and organic farmers. Many scientists are concerned that genetically engineered Bt crops will be planted widely, leading insect pests rapidly to evolve resistance to Bt toxins, and rendering Bt useless in both genetically engineered crops and as a natural insecticide. The EPA conditionally registered Bt corn and Bt cotton to require that the crops' manufacturers establish programs to prevent or slow the evolution of insect pests' resistant to Bt.

Recent conditional registrations are distinct from previous conditional registrations in the scope and kind of data they require. They are not appropriate for all products, because they involve some extra time and effort on the part of agency and company staff. However, they can be a "win-win" regulatory solution in certain situations. Conditional registrations have at least four compelling advantages:

1. *Conditional registrations build into EPA's regulatory program for pesticides powerful new incentives for companies to evaluate carefully and honestly the environmental implications of their products. If a company cannot document within a specific time period the performance it promises for a pesticide — e.g. that Bt-resistance will not evolve — the company's registration may be canceled.*
2. *The fact that companies must document their claims, which otherwise are easy to exaggerate, should give regulators considerable new confidence in the information companies provide and should boost shaky public confidence in regulatory decisions concerning pesticides.*
3. *Manufacturers should gain from the EPA's formal consideration of a company 's environmental performance predictions that now are not generally considered as part of the registration process.*
4. *Manufacturers gain orderly decisions allowing the commercialization of controversial products that otherwise might be tied up in lengthy regulatory debates.*

In short, conditional registrations are not a panacea. They have the potential, however, to enable the EPA to establish strong incentives for companies to develop pesticides that provide net environmental benefits and to practice environmental stewardship in the management of pesticide products.

Conclusion

The expanding universe of biotechnology products will broaden the range of environmental risks and controversies associated with biotechnology products. However, the diversity of new products means that while some will become the focus of new concern and debate, others may arouse little interest from environmentalists. Innovative new regulatory approaches are one way in which our society may manage better those products that spur environmental controversies.