Labelling of GM products

Consumers have a right to be informed about the products they buy. However, whether or not the labelling of GM foods is the most appropriate and feasible way to enable consumers to make informed choices about such food products is the subject of an active and ongoing debate in number of countries. It is also being debated by the Codex Alimentarius Commission. A number of governments have adopted labelling policies and procedures for GMOs, which vary substantially. Farm-to-consumer labelling protocols may pose insurmountable challenges for countries of limited capacity wishing to earn income in international markets.

GMOs and allergens

Genetic modification offers the opportunity to decrease or eliminate the protein allergens that occur naturally in specific foods. With the objective of assuring food safety, greater attention has been given to the potential risks of genetic modifications that may add allergens to the food supply. All products that contain allergens, irrespective of their origin, should be managed similarly – for example by labelling – to ensure the consumers' right to informed choice and the possibility to avoid allergens in foods. The Brazil nut-soybean (see Box) provides an example of how a potential health problem was avoided by testing before marketing.[6]

Brazil nut allergens

The possibility of transferring allergens with genetic engineering came to light when a methionine-producing gene from the Brazil nut was incorporated into soybean to enhance its nutrient content. The process was experimented by Pioneer Hi-bred in the United States. The tests conducted by their scientists on allergens, however, confirmed that consumption of the transgenic soybean could trigger an allergic response in sensitive subjects. The nature of the allergic reactions was the same as those triggered by Brazil nuts in sensitive subjects. The company, therefore, decided not to release the transgenic soybean for sale. This particular case was significant in raising awareness about the potential dangers associated with the transfer of genes in the absence of a better understanding of their functional characteristics.

[6] This paper is based on information collected up to July 2000. In September 2000, a GM maize containing a gene for a particular strain of *Bt*, which had been cleared for use as animal feed but not as human food, was found to be commercially available in a human food product. The public regulatory response was rapid, and the longer-term implications of this case are now being determined.

Golden rice and the alleviation of vitamin A deficiency

Recently, rice was genetically engineered by the insertion of three genes (from daffodil and bacteria) that generate enzymes that make the rice grains produce beta-carotene, which can be converted into vitamin A in the body. This transgenic rice produces golden-coloured grains containing enough beta-carotene to meet a person's daily requirement of vitamin A.

The potential to create rice with an enhanced micronutrient content illustrates one way in which genetic engineering can contribute to reducing malnutrition. Vitamin A deficiency, which is widespread in the developing world, can lead to morbidity and blindness and contribute to child mortality.

There are a number of alternative ways to address the problem of vitamin A deficiency, for example promotion of foods that are naturally rich in vitamin A, supplementation and fortification. These technologies are already being used and, although experts debate the merits of each approach, they are found to be effective in treating the illness. The value of GM golden rice therefore needs to be assessed in relation to these other options.

Use of GMOs in solving nutrition problems

The recent announcement that GM crop varieties can be made to produce the precursor of vitamin A (see Box on golden rice) generated considerable anticipation that products from these crops could contribute to solving the serious public health problem of vitamin A deficiency. This anticipation expanded the public debate on the role of GMOs as part of strategies to address global nutrition problems.

Scientists are also experimenting with genetic engineering techniques to prevent food safety problems. For example, genetically modified *Bt* maize, which is resistant to attacks from toxin-producing fungi, has been associated with decreased mycotoxin contamination. Mycotoxins are carcinogens and they can lead to liver cancer in humans. The fact that fewer feeding punctures from insects are found on *Bt* maize is thought to mean that there are fewer openings for fungal infection. •

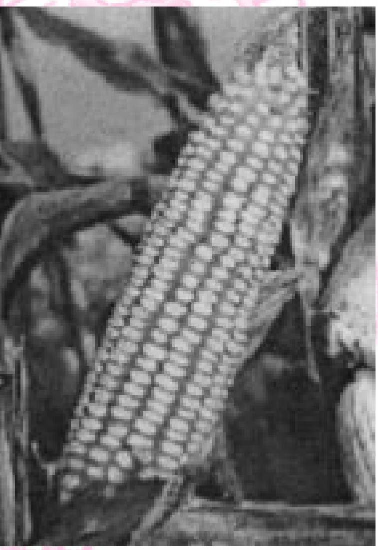
GMOs and the environment

Although the global debate on GMOs has usually allied disparate groups concerned about food safety and the environment, environmental risks are perceived to differ from food safety risks in several ways. Experience built up through decades of environmental impact studies suggests that the impact of new biological elements in ecosystems may take years or decades to be understood. The environmental impacts of introduced GMOs can be either ecological or genetic and may include:

- unintended effects on the dynamics of populations in the receiving environment as a result of impacts on non-target species, which may occur directly by predation or competition, or indirectly by changes in land use or farming practices;
- unintended effects on biogeochemistry, especially through impacts on soil microbial populations that regulate the flow of nitrogen, phosphorus and other essential elements;
- the transfer of inserted genetic material to other domesticated or native populations, generally known as gene flow, through pollination, mixed matings, dispersal or microbial transfer.

Because these potentially adverse effects have been documented in the field with non-GMO species, and because the consequences of these effects could be serious, it is important to regulate and monitor all introductions of GMOs effectively. Field experiments in ecology take months or years to become valid. Furthermore, current data on GMOs in the field should be viewed as location-specific, and extrapolations from laboratory or computer simulation to the field must be made cautiously.

Bt *maize – Problems associated with insect-resistant* **Bt** *crops are under intensive research*



ENVIRONMENT NEWS SERVICE

Environmental issues and GM crops

GM crops are commercially available and planted on more than 40 million hectares across six continents. These plantings represent the largest-scale experience in the introduction of GMOs into ecosystems, and they have become the focus of environmental concerns. Activists, worried about GMOs being released into the biosphere, have destroyed test plots in at least four continents. This may show the depth of their commitment, but it also prevents anyone from learning from the data that should have been collected from those tests.

The majority of the area under GM crops is planted with varieties resistant to herbicides. These herbicides are associated with a shift towards less mechanical tillage in large-scale arable crops, which reduces primary soil erosion. Early on, weed

Monarch caterpillar – The Monarch butterfly has generated the most detailed research into the impacts of GMOs on wild species

scientists appreciated and studied the environmental consequences of introducing GM crops, especially for weed control.

A 1998 international technical meeting, organized by FAO on Benefits and Risks of Transgenic Herbicide-Resistant Crops, found that:

1. The repeated use of one herbicide causes a shift in the weed flora because there is very high selection pressure on weeds to evolve biotypes that are resistant to the herbicides associated with transgenic plants bred to be tolerant of those herbicides.
2. Gene flow occurs with the spread of genes through pollen and outcrossing from herbicide-resistant crops to related weed species. In the absence of the particular herbicide, the possession of this trait is unlikely to improve the strength of the weeds but, when the herbicide is applied, it would improve the weeds' strength and could reduce the economic benefits of herbicide resistance.
3. The risks of gene transfers are higher in areas of origin and diversification. Care needs to be taken to ensure that native germplasm, including weed and wild crop relatives, is not affected by the transfer of herbicide-resistant genes.

Monarch butterflies and alternatives analysis of *Bt* maize

Monarchs (*Danaus plexippus*), migratory Lepidoptera that feed on milkweeds, are the best-known butterflies in North America. A well-publicized study of GMOs showed that *Bt* maize pollen was toxic to laboratory-fed Monarch butterfly larvae. A study later collected pollen-covered milkweed plants, which were found growing naturally next to *Bt* maize fields. A significantly larger proportion of Monarch butterfly larvae that fed on these field-collected plants died compared with those fed pollen-free plants.

Conventional insecticides, which are the dominant alternative for controlling pest Lepidoptera now employed in maize production in North America, also kill Monarchs and other wild butterflies. Tested alternatives within an IPPM framework include:

- **encouraging predators with intercrop management, refuges and additional food during food-scarce months;**
- **timing planting to avoid pest immigration flights (especially in tropical maize production);**
- **rotating crops to discourage the build-up of target pests;**
- **using pheromones to confuse and trap pests, reducing mating success and concentrating pests to allow lower doses of insecticides;**
- **using trap plantings to concentrate pests away from commercial crops – usually combined with better targeted applications of conventional insecticides.**

While the total area planted to insect-resistant *Bt* crops is less than one-fourth of that planted to herbicide-tolerant crops, commonly recognized problems are under intensive research. This research focuses on the applied aspects of managing agro-ecosystems for intensified production, but public attention to GMOs has also encouraged scientists in academic and other public sector institutions to carry out more basic ecological studies, especially concerning the impact of GMOs on non-target species. For example, *Bt* varieties have been found to secrete *Bt* toxins into soil root zones; these zones then produce higher concentrations of *Bt* toxins than are normally found, which may affect populations of soil insects that do not eat crops.

The prominence of the Monarch butterfly as a much-loved insect in North America, where the largest areas of GM crops are now grown, has generated the most detailed research into the impact of GMOs on wild species, as well as considerable consumer attention.

Regulatory issues, especially those related to quarantine, invasive species and biosafety become very important when GM crops move internationally, as facilitated by trade. International treaty bodies such as the International Plant Protection Convention, the Convention on Biological Diversity and the Cartagena Protocol on Biosafety are actively engaged in constructing a suitably workable framework. More specific regulatory mechanisms include the draft Code of Conduct on Biotechnology as it relates to Genetic Resources for Food and Agriculture, under development by countries through FAO.

Principle 15 of the Rio Declaration on Environment and Development (adopted at the time of the United Nations Conference on Environment and Development in 1992) states:

> "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capacities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

The Cartagena Protocol on Biosafety was adopted early in 2000, with the following objective:

> "In accordance with the precautionary approach contained in Principle 15 of the Rio Declaration on Environment and Development, the objective of this Protocol is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable

use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements ... the Parties shall ensure that the development, handling, transport, use, transfer and release of any living modified organisms are undertaken in a manner that prevents or reduces the risks to biological diversity, taking also into account risks to human health."

Environmental issues and GM forest trees

Research on the genetic modification of forest trees is undertaken almost exclusively with a view to application in plantation forestry. Today, forest plantations supply approximately 25 percent of the world's wood requirements. The area of forest plantations, which currently represents less than 5 percent of the global forest area, is expected to increase and to provide one-third of the total wood supply by the year 2010.

One of the first reported trials with GM forest trees was initiated in 1988 using poplars. Since then, there have been more than 100 reported trials in at least 16 countries, involving at least 24 tree species – mostly timber-producing species for use in intensively managed plantations. There is no reported commercial-scale production of GM forest trees.

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Regenerating shoots of transgenic poplars – Genetic modification of forest trees is studied almost exclusively for application in plantation forestry

Traits for which genetic modification can realistically be contemplated in the near future include insect and virus resistance, herbicide tolerance and modified lignin content. Modification of lignin is a potentially important objective for species grown for the production of pulp and paper. Wood with modified lignin requires less processing with harsh chemicals and is thus environmentally benign. It has also been pointed out that, as lignin content is associated with resistance to insect feeding, the overall impacts of modified lignin should be carefuly investigated. Monitoring should include possible secondary effects, such as changes in the incidence of insect damage, including in surrounding forests.

A major technical factor limiting the application of genetic modification to forest trees is the currently low level of knowledge regarding the molecular control of traits that are of most interest, notably those relating to growth, stem form and wood quality.

Investments in GM technologies should be weighed against the possibilities of exploiting the large amounts of generally untapped genetic variation that are available within forest tree species in nature.

Biosafety aspects of GM trees need careful consideration because of the long generation time of trees, their important roles in ecosystem functioning and the potential for long-distance dispersal of pollen and seed.

Environmental issues and GM fish

In the fisheries sector, most GMOs show increased growth rates; therefore, concerns about environmental risk focus more on predation, competition and genetic pollution. GM fish may pose risks to the environment because of their increased rates of feeding on prey species; their wider environmental tolerances, which allow them to invade new territories and possibly to displace local native populations; and their potential for genetic mixing with, and thus the altering of, the composition of natural fish populations. Proponents of GM fish maintain that these fish will be very domesticated and will not survive well in nature.

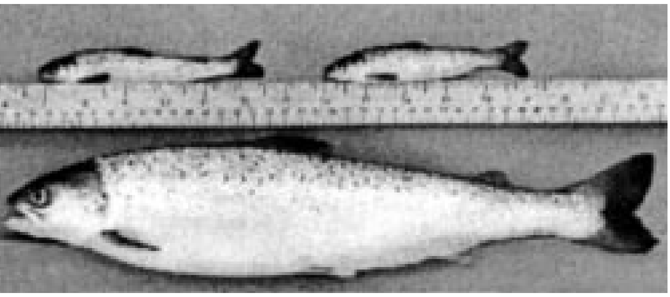
Alien species and genotypes that are used throughout the world, such as tilapia

Applying a precautionary approach to GMOs in fisheries

The North Atlantic Salmon Conservation Organization (NASCO), with more than 12 member countries, negotiated and recently began to apply elements of a precautionary approach to aquaculture and genetic modification of Atlantic salmon. Formulated during a Sweden-FAO technical meeting in 1995, the various elements are part of a dynamic process to organize regulations, standards, management and research. They force managers or policy-makers to think about what is known and unknown, what is reasonable and unreasonable, what is practical and what is impractical, and then to plot a course of action accordingly. The following are elements in this precautionary approach:

- **the lack of full scientific certainty should not be used as a reason to put off management efforts;**
- **reference points should be established to help determine desirable situations and undesirable impacts – for example limit reference points, such as a maximum percentage of GMO seed in a shipment, and target reference points, such as reduction in the use of pesticides;**
- **action plans should be identified, agreed on and implemented when limit reference points are approached or when adverse impacts are apparent;**
- **priority should be given to maintaining the productive capacity of the resource or ecosystem;**
- **the impacts should be reversible within the time frame of two to three decades;**
- **the burden of proof should be placed according to the above requirements and the standard of proof should be commensurate with risks and benefits.**

The establishment of reference points is critical and will indicate where much of the uncertainty lies as well as, therefore, where much of the monitoring, research or study is needed. In the course of NASCO discussions about the conservation of Atlantic salmon, it transpired that there were no reference points for allowable levels of genetic introgression between farmed and wild stocks of salmon.


CHEMISTRY & INDUSTRY

A transgenic Atlantic salmon, containing an antifreeze protein promoter, measured against control siblings

and domesticated salmon, present these same risks. The process of evaluating the risks of farming GMOs should be the same as for the farming of any aquatic species that is new to a local ecosystem. It should be based on an ecosystem approach that considers the spreading of impacts once a species is introduced.

Precautionary principle: an example from fisheries

Although no GM fish have been commercially released, countries concerned with salmon fishing in and around the North Atlantic have agreed to apply a precautionary approach. Earlier experiences with the collapse of populations of several species of fish of economic value in that region may have prepared fisheries policymakers from these countries to attempt this negotiation and application of the precautionary principle. •

Conclusion

During the process of development of any agricultural or food technology, there are always questions and concerns to be tackled at every stage, ranging from the yields of the product and economic gain to consumer safety and societal response. Questions such as "why is the particular product being developed?", "what are its uses?", and "who decides what is useful?" are important and need to be answered as transparently as possible.

This review of GMOs shows that the technology has the potential to affect a wide range of plant and animal products and could have many consequences. It also implies that the application of GMOs can extend beyond the food production function of agriculture.

Modern biotechnology, if appropriately developed, could offer new and broad potential for contributing to food security. At the same time, the speed of genetic change made possible by genetic engineering may represent a new potential impact on the biosphere. However, it is not possible to make sweeping generalizations about GMOs; each application must be fully analysed on a case-by-case basis. Through complete and transparent assessments of GMO applications, and recognition of their short- and long-term implications, the debate can be less contentious and more constructive.

During the relatively brief period that genetic engineering has existed, close scrutiny of the research and commercialization process has proved to be beneficial in terms of raising important issues and improving our understanding.

Citizens have a direct interest in technological developments, yet there are obstacles to their participation in decision-making that must be acknowledged and overcome. The public has not been adequately informed about the application of gene technology to food production or the consequent potential impacts on consumers' health and the environment. With the confusing array of claims, counter claims, scientific disagreement and misrepresentation of research that is present in the media, the public is losing faith in scientists and government.

Scientists, governments and the agrifood industry have now realized the need to inform the public about GMOs, yet there is relatively little information available to enable the lay person to make decisions. Widely communicated, accurate and objective assessments of the benefits and risks associated with the use of genetic technologies should involve all stakeholders. Even where access to information exists, this does not guarantee that the lay person will have sufficient knowledge and training to interpret and make use of the technical documents.

Experts have the ethical obligation to be proactive and to communicate in terms that can be understood by the lay person. Some professional associations have recognized this and have called for the education of the general public on genetic technologies and principles.

There need to be more opportunities enabling the exchange of information among scientists, corporate representatives, policy-makers and the public at large. Including members of the public on advisory committees set up for the formulation of laws, regulations and policies would help to ensure that their perspectives were fairly represented.

Fora that enable citizens to voice their views can be a routine and integral part of analysing GMO issues and making decisions. National, regional and international fora need to be clearly identified and their respective roles clarified to provide efficient mechanisms for discussing specific issues, reaching relevant agreements and devising appropriate instruments for their implementation.

The right to adequate food, as understood today, carries with it obligations on the part of states to protect individuals' autonomy and capacity to participate in public decision-making fora, especially when other participants are more powerful, assertive or aggressive. These obligations can include the provision of public resources to ensure that those fora take place in a spirit of fairness and justice. •

Abbreviations

Bt
Bacillus thuringiensis

DNA
deoxyribonucleic acid

GM
genetically modified

GMO
genetically modified organism

IPPM
integrated pest and production management

LMO
living modified organism

NASCO
North Atlantic Salmon Conservation Organization

NGO
non-governmental organization