CHAPTER 13

Environmentally-Sound Technology Assessment and Transfer for Biodiversity

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Abstract

One of the largest problems facing humanity today is the balancing of population growth, biodiversity conservation and economic development. In the course of trying to overcome these problems, more problems may be created which may threaten the survival of the very species the programmes were meant to protect. Modern biotechnology which, according to its proponents, is a safe efficient way to produce higher agricultural yields from less land, in addition to pharmaceutical products, has proved to have serious ecological health and socio-economic hazards. There is a fear that, driven by the profit motive, some unscrupulous companies could use the developing countries as testing grounds for insufficiently researched biotechnologies that could pose a threat not only to biodiversity but to human health as well. There is need for an international regulatory mechanism to streamline (especially trans-boundary) transfer and handling of products of biotechnology, especially genetically-engineered organisms in order to save the future. Governments, especially in the Third World, need to build up capacity in biotechnology to assess and manage any potential risks if we are to benefit from technology transfer.

INTRODUCTION

The Convention on biological diversity, which was signed in Rio de Janeiro in 1992 and ratified by most of the world's governments ever since, has the main objective of saving the world's biodiversity. To preserve biodiversity, the growth of the world's population must be controlled and wild natural ecosystems must be conserved. Modern technological advances provide tools for producing more food and fibre from less land, thereby addressing the need for biodiversity conservation. One of the technological tools to boost agricultural production is genetic engineering. According to BIO (Biotechnology Industry Organisation), "more than 7,000 successful field tests around the world have demonstrated that genetic engineering is a safe, efficient way to produce higher yields from less land".

For today's developing countries to become economically viable, they need a strong agricultural base. However, as the poor struggle to survive, protecting the environment becomes a secondary concern. But a viable agricultural economy can alleviate poverty and hunger which tear apart the environment in developing countries. From what has been done in the past decade, biotechnology will have a profound effect on the ability to provide organisms with many new properties. Hopefully, it will be possible to provide plants and animals with enhanced resistance to pests and diseases; have modified protein and oil content; and have improved nutritional properties; resistance to environmental stress such as drought, high salinity, or cold. Biotechnology also has a potential of providing new pharmaceuticals and other substances synthesised *in situ* within crop plants or animals in environmentally-acceptable ways.

However, the introduction of foreign genes derived from unrelated organisms into crop plants and even synthesise genes in the laboratory has raised concern among some people. For example, the insertion into plants of a *Bacillus thuringiensis* gene responsible for the production of an insecticidal protein may give rise to the evolution of insecticidal resistance in insect pests, triggered by continued exposure to insecticidal properties in transgenic crops.

The potential of biotechnology

In an attempt to reduce on the amount of chemicals applied in agricultural fields while at the same time increasing yields, research is being conducted to produce pest and disease resistant crops.

Examples of on-going work

1. **Paw paws**: In Brazil, which is one of the major producers of papaya in the tropical world, transgenic technology is being used to develop Ring-spot (the major disease affecting the crop) virus-resistant papayas. If successful, this could increase production in Brazil and later in other producing countries.

2. **Cotton**: Cotton growing in the Third World is affected by the multiplicity of pests, making it the highest user of insecticide compared to other crops of the world. In Brazil, selected personnel have been equipped with the training necessary to develop an insect-resistant cotton. They are using *Bacillus thuringiensis* (Bt), a naturally-occurring bacteria in the soil that produces proteins toxic only to certain insects. Growing of genetically-engineered, insect-resistant cotton could lead to a significant reduction in

insecticide application, hence a reduction in costs and the associated pollution.

3. **Tobacco**: In an attempt to provide for their high population, China has invested heavily in Biotechnology. Consequently, China has produced genetically-modified tobacco since 1992. Heavy metals like Cadmium pollute farmlands in China. Researchers from Peking University have developed a transgenic tobacco plant that absorbs Cadmium. It is hoped this technology will clean up their environment so that farmers can harvest crops without heavy metal contamination.

4. **Banana, Pineapple and Melon**: In Costa Rica, research is being done on these crops. It is aimed at producing banana and pineapple that will produce more fruit in less time. For the melons, the aim is to impart resistance to the Cucumber Mosaic Virus. This technology could later spread to other countries thereby boosting production.

5. **Potato, Corn, Cucurbits and Tomato:** Research is under way in Egypt to introduce, through genetic engineering, resistance to the potato tuber moth. The resistance gene is again from *Bacillus thuringiensis*. With corn, research is aimed at imparting resistance to the various species of stem borers that wreak havoc on Egypt's corn production. Work on cucurbits is aimed at imparting resistance to virus infection while research on the tomato is supposed to transfer resistance to the yellow leaf curl, a viral disease.

6. **Corn, Pineapple, Coffee, Bananas and Ornamental plants, Rice, Irish and Sweet Potato, and Peanut:** In Indonesia research is being done on various crops, in addition to training local scientists in genetic engineering. Research is being done on the following crops as outlined below:

   (a) ***Corn*** – Research is being done on corn borer-resistant maize.
   (b) ***Pineapple*** – Improvement of yield and quality to make them more economically feasible.
   (c) ***Coffee, Banana and Ornamental Plants*** – Improvement in propagation techniques.
   (d) ***Rice*** – Biotechnological research.
   (e) ***Irish and Sweet potato*** – Research is aimed at developing disease-free planting materials and imparting insect resistance respectively.

(f) ***Peanut*** – research is aimed at producing peanut cultivars resistant to peanut stripe virus.

7. **Sweet potato:** One of the greatest plagues affecting the sweet potato crop in Africa is the Sweet Potato Feathery Mottle Virus (SPFMV). In Kenya, research began in 1991 aimed at producing a potato resistant to the SPFMV. The task is to add virus resistance to locally-adapted sweet potato varieties grown by African subsistence farmers. If successful, this research could make a major contribution to food security for some of the poorest farmers of the world.

8. **Timber, Rattan and Bamboo, Rice, Papaya**

(a) ***Timber, Rattan and Bamboo*** – The development of the forestry sector is often hampered by lack of planting materials, due to the long periods taken to produce seed. Vegetative propagation techniques are being developed in Malaysia to overcome shortage of planting materials and to provide a rapid means of propagating superior genotypes. Rattan and Bamboo are being micro-propagated. This technique could be a viable technological option for the Third World, considering the ease to store large quantities of planting stock without interfering with utilisation of the mother stock, in addition to having fewer uncertainties since there is no genetic alteration.

(b) ***Rice*** – In the same country, research is being done on rice using genetic engineering to provide protection against the Rice Tungro disease which often devastates the crop.

(c) ***Papaya*** – Research is being carried out to impart resistance to papaya Ring Stop virus, through genetic engineering.

9. **Biotechnology development in South Africa**: In South Africa, the main thrust of the plant Biotechnology programme has been the isolation of novel genes for crop improvement, especially fungal, insect and drought resistance; plus development of transformation systems for specific crops. Work is under way on herbicide resistance in soya beans; modifying tomatoes; genetic manipulation of maize; and improvement of sunflowers.

Other work includes:

(i) Improved rooting for seedlings and development of somatic embryogenesis for propagation of commercial tree varieties;

(ii) Investigation of local germ plasm for valuable pharmaceuticals; viral resistance in local ornamental bulbs, cucurbits and potatoes;

(iii) Fungal resistance genes for cotton and tobacco; and

(iv) molecular markers for grasses, grapes, potatoes and alfalfa; *Bacillus thuringiensis* (Bt) genes for cotton boll worm and herbicide resistance in soya bean, and many others.

10. **Other initiatives**: Genetic engineering research is being done with funds from the World Bank, European Union, Zeneca Plant Sciences and the University of Belgium, using anti-fungal proteins to confer resistance to Black Sigatoka disease (a fungal disease) in both bananas and plantains. Though directed to all banana and plantain-producing countries worldwide, the largest research effort on plantains is in Nigeria and on bananas in Honduras. Fungi resistant bananas and plantains will decrease the use of chemical fungicides.

The need to regulate and control genetic engineering (biosafety)

In nature, whenever an organism evolves, it co-evolves with its natural enemy that is adapted to living with it and somewhat regulating its population growth. This naturally ensures that no species can become a noxious weed and pest, unless the natural control mechanisms have been tampered with. The creation of transgenic organisms through genetic engineering could therefore pose some ecological problems, since it is often not possible to duplicate field conditions in the laboratory.

The new biotechnology based on genetic engineering makes the assumption that "each specific feature of an organism is encoded in one or a few specific, stable genes so that the transfer of these genes results in the transfer of a discrete feature". However, this extreme form of genetic reductionism has been rejected by the majority of biologists, and many other members of the intellectual community because it fails to take into account the complex interactions between genes and their cellular, extracellular and external environments that are involved in the development of all traits. It has thus been impossible to predict the consequences of transferring a gene from one type of organism to another in a significant number of cases.

Of particular concern is the difficulty or impossibility of recalling GEOs that have been either deliberately or accidentally released into the environment and later found to have adverse effects. The release of GEOs into the environment has a potential to disrupt radically the dynamic pattern of functional relationships which underpin both evolution and ecological stability.

Whereas it is known that some traits of organisms take decades to manifest themselves ecologically, observations of most GEOs cover only a few years. An organism declared safe in the short run could prove hazardous in the long run.

Ecological, health and social risks of genetic engineering

Several years of research and analysis have found that there are serious potentials for adverse effects of genetic engineering and Genetically Engineered Organisms (GEOs) on the environment and on human health. The ecological risks of applying genetic engineering to agriculture include the possibility that some transgenic crops could become noxious weeds and affect wild ecosystems. Plants engineered to express toxic substances such as insecticides and pharmaceutical products could poison non-target organisms, including beneficial ones.

The use of conventional pesticides involves intermittent exposure of the pests to the toxins, when an attack is eminent, as opposed to when the pesticide genes are engineered in the plant. In the latter case, the toxin is continually produced and the pests continually exposed to it. Under such conditions, an extremely strong selection pressure is created in the pests for the rapid evolution of resistance to the toxin. In the process of the pests reacting to the selection pressure towards survival, they would adapt new survival strategies adapting their behaviours as well as their genetics in highly unpredictable ways.

There is a possibility that plants engineered to contain viruses and/or fragments of viruses (in order to become virus-resistant) may facilitate the creation of new viruses or increase the host range of the existing viruses that can cause new plant diseases. The addition of novel adaptive traits to "wild type organisms" would give some of them a competitive advantage and cause them to overrun natural communities of fauna and flora thus reducing natural biodiversity. Transgenic crops pose a threat to wild plants and farmers' varieties which are major sources of crop genetic diversity. This is possible through the competition that could result from pollen transfer from transgenic crops to their wild relatives. The loss of wild relatives and farmers' varieties would deprive the world of some of the most valuable resources needed for improving agriculture and for securing future food security. Genetic engineering may also favour monocultures and erode agricultural diversity, and especially threaten the global centres of crop diversity located in developing countries.

Transgenic crops and their non-genetically engineered and even wild relatives could exist together under field conditions, transfer of genes from GE crops to the weedy relatives could pose remarkable problems. The transfer of herbicide resistance to weeds could clearly cause enormous problems to weed control by reducing the effectiveness of specific herbicides which, in turn, could lead to farmers using stronger and perhaps more hazardous chemicals.

The effects of genetic engineering on human health can not be overlooked. The death of dozens of people and the crippling of dozens in North America around 1989 after consuming a batch of food containing L-tryptophan, produced using genetically-engineered bacteria, should be an eye-opener on the potential health problems posed by genetic engineering. The case could have been more pathetic in a Third World country, especially when food labelling requirements are not being enforced to enable epidemiologists establish a pattern between consumption and illness. The risk in the Third World is worsened by the low levels of expertise in biotechnology and the lack of an effective legal and regulatory capacity to monitor, assess, and manage risks related to GEO releases.

Some biotechnology agencies have claimed that genetic engineering "is safe" because there have been hundreds of "releases" of GEOs into "test plots" and that "nothing dangerous has happened". This, however, ignores the fact that these have not been true releases since the plots have been confined, not to mention the length of time over which the so-called safe tests have been observed. It is therefore scientifically imprecise and misleading to claim that there are no negative impacts since nothing unexpected has happened in the short run.

It should, however, be recognised that a significant number of individual projects can be done safely. This should not produce a false sense of security though. It would be extremely dangerous for developing countries to accept uncritically advice about safety and effectiveness from the biotechnology industry and governments of industrialised countries which are deeply committed to reaping profits from their enormous investments in biotechnology, and thus would tend not to give objective assessment or advice.

Proponents of modern biotechnology mobilise support from the public by making claims that biotechnology is the key to feeding the world and finding new cures for diseases. The technology, however, is imposed on a public which is largely excluded (or incapacitated) from decisions over its direction, desirable limits and value. This is particularly disadvantageous to the developing world.

Despite several claims by GEO advocates that it has a potential to bring significant benefits to the developing countries, by an increase in yields, drought tolerance and pest resistance, analysis of genetic engineering programmes currently under way shows that the majority of them are focused on potential GE applications for the North (developed countries). Not only do they ignore problems and circumstances in the South but many are developing programmes likely to reduce demand for primary products from developing countries (which are heavily dependent on agriculture). It goes without saying that such global shifts in the production of primary products will have major impacts on the conservation and sustainable use of biological diversity (WWF, 1995).

The way forward

There is clearly need for an appropriate international biosafety regulation that is legally binding, such as the biosafety protocol currently being negotiated under the auspices of the secretariat to the Convention on Biological Diversity (CBD), to regulate the transfer, handling and use of Living Modified Organisms (LMOs), in accordance with Article 8 (g), and 19.3 of the CBD. This should follow the precautionary principle proposed in the CBD.

Expanded and adequate resources should be made available (say in accordance with Article 20 of the CBD) for scientific and objective assessment and management of risks associated with effects of genetic engineering.

1. All trans-boundary movements of LMOs should be subjected to the Advance Informed Agreement (AIA) procedure which should be handled by the Competent Authority designated by the recipient country for that purpose.

2. Both governments and industrial concerns should urgently strive to adopt a culture of safety, according high priority to safety and health considerations.

3. Governments should set up national registers of past and present genetic-engineering experiments/projects in order to establish an effective monitoring system as part of standard safety measures.

4. There is need for an international register (say under the CBD secretariat) where information on worldwide activities regarding releases of GEOs can be accessed by parties as part of a safety and monitoring system. This should be characterised by high levels of transparency and honesty.

5. Genetic engineering should not be looked at as the panacea for all the world's problems but rather a more holistic approach should be adopted. Do not do things simply because they can be done, but because they must be done!

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