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# Multi-author Reviews

# Gene technology and biodiversity

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## Introduction: Gene technology and biodiversity

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The following Multi-author Review represents most of the principal contributions to the symposium 'Gene Technology and Biodiversity: On the Risk Assessment of Genetically Modified Organisms (GMOs)'; organized by the Swiss Academic Society for Environmental Research and Ecology, (Schweizerische Akademische Gesellschaft für Umweltforschung und Oekologie - SAGUF), held 2 October 1992 in Basel/Switzerland as a part of the annual meeting of the Swiss Academy of Natural Sciences that itself was devoted to the question: does biodiversity have a chance in the future?

### *The aim of the SAGUF symposium*

Ever since its foundation twenty years ago, it has been the aim of SAGUF to bring together the protagonists involved in the development of new technologies and those affected by the consequences of their implementation in our society. SAGUF believes that it is only through such participative processes that solutions to current or future problems can be found and premature decisions avoided that might have to be withdrawn at a later stage at a very high social cost.

### *The potential of genetic engineering*

Through genetic engineering, genes can now be isolated, modified, equipped with strong expression signals (mostly derived from plant pests) and implanted into foreign organisms, regardless of the genetic relatedness of recipient and donor. The overcoming of genetic barriers now made possible obviously represents a technical revolution with enormous potential applications for plant breeders. But what will be the ecological consequences of the massive releasing of genetically modified organisms? What exactly will we define as 'negative consequences' for nature and society, and what observation time-scales are to be considered in order to provide judicious criteria on their ecological impact?
The consequences of the deliberate release into open spaces of GMOs has turned out to be a really intricate and highly politicized matter, as not even the biologists' community, especially ecologists and molecular biologists, agrees on what the consequences might be. Both the ecological uncertainties and the industrial pressure to commercialize such specimens have provoked strong criticism in some spheres of public opinion, especially in Germany and Switzerland, countries that have become highly sensitive to environmental matters due to the awareness of the ecological crisis of our planet.
In this context the symposium 'Gene Technology and Biodiversity' was a successful attempt to bring together scientists from different biological disciplines involved in the risk assessment of GMOs. It served to clarify ecological concepts and made the audience acquainted with experiences, observations and findings gained when dealing with biological invasions of foreign species introduced into new ecosystems. Most of the speakers invited to the symposium are scientists that have been involved with committees or organizations dealing with the risk assessment of transgenic organisms.

### *Worldwide releases of GMOs and their ecological impact*

J. Duesing from Ciba-Geigy Seeds, Basel, presented statistics on the increasing number of worldwide field trials with transgenic plants since 1986, the year the first 5 releases were conducted: in 1991 alone, 156 field tests were carried out, adding up to a worldwide total of almost 400 releases[2]. Until 1991, the main countries involved in this process were the USA with 141 field trials, France with 83 and Canada with 52. Most of the introduced traits of the 1991 releases conferred herbicide tolerance (56 cases out of a total of 155), virus resistance (25 cases), insect resistance (24 cases), or were intended to increase the product quality of the transgenic plants (26 cases).
So far, no negative ecological consequences caused by the introduction of transgenic crop plants have been reported. This has to be regarded as a provisional statement on the situation. Questions on the thorough-

ness of the ecological impact assessment remain open, as was recently shown in an analysis by ecologists from the Tufts University of Massachusetts[4]: the majority of the mandatory environmental assessments for field trials presented to and approved by the US Department of Agriculture contained 'unsubstantiated statements' on the ecological risks of the transgenic plants to be released.

*Deliberate release of GMOs in Switzerland*

The process of deliberate releases in Switzerland is much less 'developed' than in many other industrialized countries. At present, there has been just one field trial with a transgenic potato, made resistant against a pest (the aphid-transmissible potyvirus $PVY^N$) by implanting the gene encoding for the viral coat protein into the plant genome. One of the main concerns and criticisms surrounding the deliberate release of transgenic plants expressing viral coat proteins is the possible creation of 'new' viruses with a broadened host spectrum[5].

P. Malnoë, who conducted the field trial over two successive years at the Station Fédérale de Recherches Agronomiques de Changins/Nyon, presented data confirming the mixed encapsidation upon mechanic infection of the transgenic potato with a related RNA-genome virus (potyvirus $PVY^O$)[3]. Although the heterologous capsid is only produced in the first generation of the virus (as it is not expressed from its own genome), the ecological consequences of such viruses with mixed capsids are unknown.

*Adaptations to changing environments*

It has been suggested that GMOs will be poor competitors and therefore unable to persist in nature due to energetic inefficiency, disruption of genomic coadaptation or domestication. Although often true, R. Lenski (Center for Microbial Ecology, Michigan State University) presented counter-examples in which genetic modifications unexpectedly enhanced competitive fitness. These experiments show the notable genetic plasticity of microorganisms adapting to adverse conditions.

*The 'Introduced or exotic species model'*

GMOs will not be inherently or uniformly crippled; on the contrary, viable and competitive individuals will be selected for introduction into the environment. P. Regal (Dept of Ecology, University of Minnesota) emphasized the usefulness of the 'Introduced or exotic species model' that deals with experiences from past (wanted or coincidental) introductions of exotic species into new ecosystems to be a realistic model to predict the possible implications of the release of GMOs. Although the properties of transgenically modified crop plants that have been domesticated by many generations of breeding (such as maize plants) might pose few ecological problems, the model will be especially valuable when dealing with transgenic organisms that have only been domesticated to a low degree (e.g., pasture grasses or forest trees).

When dealing with released transgenic plants, two of the main concerns are the spread of their properties to related weedy species through hybridization and the establishment of feral populations of crop plants. Extensive floristic data for both processes were presented by H. Sukopp (Institute of Ecology, Technical University of Berlin). Hybridization processes are common in nature, and almost all of today's most common cultivated plants form weed races.

According to observations of the British flora, 10% of introduced species become established and 10% of the established become pests or weeds (10:10 rule). M. Williamson (Dept. of Biology, University of York) demonstrated the difficulties in predicting the weediness of plant species. Comparison of characters of closely related species shows that small morphogenetic differences can coexist with large ecological differences. The implication for the release of GMOs is that minor gene differences can have major effects. This alone justifies proper field trials and monitoring.

*Interdisciplinary risk assessment research required*

There was general agreement at the symposium that research in the field of risk assessment has to be notably increased before conclusions on the ecological impact of GMOs can be effectively drawn up. The complex character of the ecological interactions of released new species with their environment makes prediction a very difficult task. There is actually no generalized prediction on the behavior of released GMOs possible; therefore, we have to rely on empirical models from the past of the behavior of released exotic species. While only approximately 1% of those species became weeds, they have caused serious ecological and economical problems. Possible effects can only be studied as part of a long-time series of observations.

K. Ammann (Botanical Institute, University of Berne) argued in favor of a strong interdisciplinary collaboration between molecular biologists who tend to analyze life under controlled experimental conditions in systems with limited parameters, and field ecologists who work mainly with observation methods in complex ecosystems with many feedback mechanisms, where predictions are difficult and long time-scales have to be taken into account. Despite its complexity, the present situation is also a chance for a collaborative process between different biological disciplines that, along with the vertiginous development of molecular biology, have increasingly separated.

A first step in this direction was presented at the symposium: an incipient risk assessment and product security

module, as part of a new federal biotechnology research program ('Schwerpunktprogramm Biotechnologie' of the Swiss Nationalfonds), will set up a coordination office to provide and to evaluate information, and to help to implement new research projects dealing with the risk assessment of GMOs in Switzerland.

### *A social 'shaping' of nature*

When dealing with the release of GMOs, not only scientific questions concerning their ecological consequences have to be considered but also ethical and political aspects concerning our societies and their changing values.

Ch. Rehmann-Sutter (Biocenter, University of Basel) stated that GMO releases transcend the politically and morally neutral space normally surrounding scientific experiments (laboratories, greenhouses and other contained spaces) because they take place in public spaces. As a 'social shaping' of nature, they are political in a fundamental sense. They raise questions about the legitimacy of decisions and possible procedures of decision making. Laws are required that consider the need for impartial information on the opportunities and risks of this new technology and for a democratic participation of the public.

### *SAGUF-theses concerning the release of transgenic organisms*

Parallel to the symposium, the Board of SAGUF released a series of theses concerning the release of transgenic organisms[1]. These theses are in accordance with the results of the conference.

*Thesis 1.* The phenotype of a genetically modified organism (GMO) cannot always be predicted from its genotypical properties. Multiple pleiotropic effects (various side-effects on other genes or their products) may occur at the ecological, physiological or morphological level, causing unexpected interactions with other species.

*Thesis 2.* The aim of an ecological risk assessment is to provide sufficient information on the subject so that statements such as 'very small' or 'very unlikely' can be avoided. Deliberately released GMOs shall be regarded at least as exotic species that, due to a missing evolutionary adaptation, might develop unexpected population dynamics at the expense of domestic species. Therefore, GMOs must not be released on common agricultural areas; even on restricted experimental fields, special security measures should be applied.

*Thesis 3.* A mandatory risk impact assessment should be performed before any GMOs are released, accompanied by a certificate of requirement (otherwise only required for public works). Of course, conventionally bred new sorts and non-native cultivated plants should also be submitted to this regulation.

*Thesis 4.* Regulations must be based on scientific criteria and on the active exchange of information. The complex character of assessing the potential risk of released GMOs requires the participation of ecologists and both evolutionary and population biologists in the decision process. We consider the creation of an 'Interdisciplinary Institute for Biotechnology Research' with a department on biological risk research as being an important flanking measure. Although thorough scientific expertise is absolutely necessary, the responsibility for far-reaching decisions cannot be burdened on the scientific community exclusively. Explicit parliamentary decisions are required; the political establishment will have to accept responsibilities for the consequences of the decisions taken.

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