ENVIRONMENTAL RISK ASSESSMENT
OF GENETICALLY MODIFIED PLANTS

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ABSTRACT
In order to fulfil the requirement of the guidance notes supplementing Annex II to Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms the current environmental risk assessment of genetically modified plants needs to be improved. By adopting a quantitative and predictive environmental risk assessment methodology it is possible to aid decision making by improving the current methodology of the environmental risk assessment of genetically modified plants. Furthermore, the tools developed in such a quantitative and predictive environmental risk assessment approach are essential in constructing a decision support system that potentially will enable comparison of environmental effects, costs and benefits of different agricultural strategies (e.g. organic farming, conventional farming using pesticides and GM-farming) for assessments of social efficiency and sustainability.

INTRODUCTION
The first commercialisation of transgenic plants in Europe on a large scale is likely to occur within a short time period and soon the next generation of transgenic plant with more advanced traits in different combinations will be put on the market. Prior to this there has been a long regulatory process and the hearing of many different experts on risk related issues. Simultaneously, environmental risk assessment (ERA) of genetically modified plants (GMP) has developed from the first comprehensive review article presented in the late eighties (Tiedje et al. 1989). This review was primarily based on speculations and its focus was primarily on agronomic concerns (creation of new pests, resistance development etc.) and on the structure of international co-operation. Since then, scientists have gone through a period of optimism concerning the risks of GMP exemplified by Crawley (Crawley 1992), into a phase of growing concerns with the environmental consequences of GMP simultaneous with an increasing amount of relevant data (Tomiuik et al. 1996). In the nineties the discussion was further expanded from a scientific debate of biological consequences of releases to include ethical considerations (e.g. Potthast 1996). At the same time the regulatory and legal aspect of commercialisation has become a major issue (Tomiuik et al. 1996). Most recently, studies incorporating valuation of benefits through quantitative assessments of consumers' preferences towards products containing GMP’s and related issues have just begin to evolve (Bredahl 2001, Chern and Rickertsen 2002, Lusk et al. 2003). Today we are at a stage where a lot of relevant data has been collected and the most important ecological characteristics which may cause adverse environmental effects has been identified (Strandberg et al. 2001, Hails 2002). However, no internationally standardised and consistent schemes, test procedures and concepts have been adopted in order to make a coherent ERA, linked to the commercial use of GMP and analyses of the social costs and benefits of the use of GMP.

In many cases introduction, of new species or genotypes to an area is an irreversible process. If a plant species first is introduced into a natural habitat it may not be practically possible to remove it again or management to restrict further dispersal may be costly. Therefore, it is important to make a
comprehensive assessment of the possible environmental risks of the GMP before it is released for commercial growing. In a scientifically based risk assessment, the magnitude of a risk is measured as a function of the probability that a specific event occurs and the negative impact of the event (e.g. Vose 2000). Recently, this definition of risk has been adopted by the EU commission in the procedure for ERA of GMP (guidance notes supplementing Annex II to Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms) (EU 2001, 2002). However, this type of ERA procedure, while methodologically superior (e.g. Damgaard and Løkke 2001, Damgaard 2002) (step 2 and 3 in Fig. 1), deviates in many aspects from the currently employed methodology and it is still unclear how the Directive 2001/18/EC should be implemented at a detailed level. The ERA of GMP in the EU countries has until now been conducted mainly by the use of qualitative expert opinions.

Fig. 1. The six steps in the analysis of ERA of GMP as outlined by the guidance notes supplementing Annex II to Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms (EU 2002). Figure copied from (EU 2002).

The methodology of estimating probabilities is well defined and based on concepts that are generally used in the scientific community. It is possible to predict the likelihood of specific ecological or evolutionary scenario (an identified adverse effect) at different environments by integrating theoretical ecological modelling with experimental data and advanced statistical methodology. For example, an operative and quantitative methodology for predicting the probability that a GMP invades a natural habitat and outcompetes naturally occurring species has been developed from information of seed dispersal and data from relatively simple competition experiments (Damgaard 1998, 2002, Damgaard and Jensen 2002).

It seems apparent that the possible risks of growing GMP should be evaluated in a broad context, and linked to cost-benefit analysis of the use of GMP’s in the food production chain. If the benefits of growing a specific GMP are many and/or important, society – represented by consumers’ - may be
willing to accept larger risks compared to the risks associated with a GMP, which is thought to be less beneficial. Furthermore, different agricultural strategies (such as organic farming, conventional farming including pesticides, and GM-farming) may cause different cost and benefits, including risk considerations among consumers and experts. These should be described and included in the decision process of which agricultural strategies are preferable with respect to cost-efficient regulation and sustainability. For example, extensive use of pesticides is undesirable due to possible negative effects on the environment and human health.

In order for the society to choose efficiently between different options it is essential that the benefits and costs associated with the options, including any environmental risks, are known and compared in a systematic way. An environmental risk may be perceived as a possible future cost in a cost–benefit analysis of different agricultural strategies. However, where market prices cannot be used to estimate the value of costs and benefits of e.g. agricultural produce, we need to use non-market valuation techniques (Braden and Kolstad 1991) to estimate the economic value of environmental impacts, including impacts on biodiversity (Navrud 1993, Loomis and White 1996). Stated choice methods can be applied, and most recently, such techniques have been used in experimental set-ups to assess the social benefits of GMP’s in agricultural products, and to compare these benefits, perceptions and attitudes to GMP’s across countries (Bredahl 2001, Chern and Rickertsen 2002, Lusk et al. 2003).

OBJECTIVES FOR THE FUTURE

It is important to integrate socio-economic and ecological methodologies into an integrated quantitative and predictive ERA methodology of GMP in order to aid decision making by improving the current methodology of the environmental risk assessment of genetically modified plants, in a way outlined in the guidance notes of 24/7 2002 to Annex II to Directive 2001/18/EC (EU 2002) (Fig 1), and to develop tools that are essential in a decision support system that potentially will enable comparison of environmental effects, costs and benefits of different agricultural strategies (e.g. organic farming, conventional farming using pesticides and GM-farming) for assessments of social efficiency and sustainability.

Furthermore, a quantitative and predictive ERA will enable systematic strategies for possible mitigation of the adverse effects connected to the commercial growing of GMP, and the validation of the specific quantitative and predictive ERA will, in a natural and logic way, lead to strategies for suggested case-specific monitoring programmes with inherently established endpoints and criteria.

In order to reach the above objectives the following tasks needs to be carried out:

1. Assessment of costs and benefits of GMP’s and the environmental effects of GMP, compared to conventional produced agricultural plants. The step contains three stages, i.e. assess the costs of using GMP, estimations of European consumers’ willingness to accept GMP/willingness to pay, when informed about the scientific environmental effects and the probability of these effects to occur and cost-benefit analysis.

2. Scientific ecological research for predicting the probability that different ecological or evolutionary ecological scenarios (the identified adverse effects) will occur, with a known degree of uncertainty, based on ecological data that may be obtained with a reasonably amount of experimental work. In some specific cases of identified adverse effects it may be too difficult within a reasonable amount of experimental work to make quantitative predictions of the likelihood of specific ecological or evolutionary scenarios with a sufficient precision to be relevant in the ERA of GMP. In those cases the objective will be to delimit the cases of identified adverse effects where a quantitative and predictive ERA is not feasible and a qualitative methodology should be used instead. This possible change of objective corresponds to the guidance notes to Directive 2001/18/EC where it is stated that: “For each adverse effect identified the relative likelihood of the consequences can probably not be assessed quantitatively, but it can be expressed in terms of high, moderate, low or negligible”. Furthermore, a quantitative
and predictive ERA will enable systematic strategies for possible mitigation of the adverse effects connected to the commercial growing of GMP, and the validation of the specific quantitative and predictive ERA will, in a natural and logical way, lead to strategies for suggested case-specific monitoring programmes with inherently established endpoints and criteria.

3. Development of a framework for integrating the results of the socio-economic and ecological parts of the ERA of GMP by combining general socio-economic and environmental risk assessment methodologies for assessing the risk of events that occurs with a known probability.

REFERENCES


