Keynote Address -
Conference on "Crop and Forest Biotechnology for the Future
Royal Swedish Academy of Agriculture and Forestry
Falkenberg, Sweden 16 to 18 September 2001

Genetically Modified Organisms in Food and Agriculture: Where are we? Where are we going?

September 2001[i]

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Perceptions

Genetically modified organisms (GMOs) are a fact of modern agriculture, and are here to stay. GMOs are also a fact of public preoccupation and opinion, which politicians must take into account. FAO recognizes the great potential and the complications of these new technologies. We need to move carefully, with a full understanding of all the factors involved. In particular, we need to assess GMOs is terms of their impact on food security, poverty, biosafety, and the sustainability of agriculture. Will GMOs increase the amount of food in the world, and make more food accessible to the hungry? Clearly, GMOs should be seen not in isolation as technical achievements. Hence, I will discuss not the specifics of GMO technology, but the context in which they are developed and deployed, and about how public opinion and government policy on GMOs are formed.

The public in many countries distrusts GMOs. They are often seen in the context of globalization and of privatization and even as “antidemocratic” or “meddling with evolution”. There are as yet few perceived advantages for the public, because GMO applications to date have concentrated on reducing costs for producers without direct consumer benefits. In particular, it has been a tactical error of the industry to concentrate on pesticide-resistance as one of the earliest applications, as this has stimulated environmental concerns. The public often confuses the industry with the science. And consumers worry about risk, not about scientific freedom.

Scientists in both the private and public sectors clearly see genetic modification as a major new set of tools. They are also participants and spectators in a major shift of research from the public to the private sector, which will undoubtedly influence the future direction of research and research investment. As shareholders in the GMO debate, scientists must recognize that there is also a substantial public distrust of science.

Obviously, the industry looks at GMOs as opportunities for corporate profit yet, at the same time, recognises that public acceptance may be a stumbling block. In turn, governments often lack coherent policies in relation to GMOs, and have not yet developed and implemented adequate regulatory instruments and infrastructures. As a result, in most countries, there is no consensus on how biotechnology and GMOs in particular can focus on the key challenges of the food and agricultural sector. Governments need to be more proactive in addressing these questions and, in this, the role of scientists in public service will be crucial.

GMOs: where are we?

We cannot talk intelligently about GMOs if we remain at the level of generalities. Any statement must refer explicitly to specific crops, genes, ecologies and production systems. For this reason, FAO has been conducting a worldwide inventory of agricultural biotechnology applications and products, with special reference to developing countries. We wished to test the hypothesis that biotechnology has been uneven, and that most current biotechnology applications in crop science — particularly GM crops — have not addressed the special needs of developing countries. We have looked specifically at current as well as pipeline research on GM crops. Our sources of information have been varied, informal discussions with scientists as well as formal reports. Our inventory will be available electronically and will be updated regularly. Some of the preliminary results are as follows.

The total area cultivated with GMO crops in the world currently stands at about 44.2 million hectares. This compares with 11 million hectares only three years ago. About 75% of the area planted to GM crops is in industrialized countries. Substantial plantings so far largely concern only four crops: soybean, maize, cotton and canola, and about 16% of the total area planted to these major crops is now under GM varieties. Two traits – insect resistance (mainly based on Bt) and herbicide tolerance – dominate. There are also small areas of potato and papaya, with genes for delayed ripening and virus-resistance inserted.

Only seven developing countries commercially cultivate GMO crops, and, with the exception of Argentina and China, the areas involved are less than 100,000 hectares. Here again, the dominant crops are soybean and cotton, and the traits are herbicide tolerance and insect resistance. Only in China one of GM cotton was locally developed and commercialised. Other countries obtained genetic constructs or varieties from industrialised countries.

Although several forest tree species, such as conifers, poplar, sweet gum and eucalypts, have been transformed using recombinant DNA technology, they have not so far been released for commercial purposes. Tropical fruit tree species seem to have been largely neglected.

Current releases are still very narrow in terms of crops and traits and countries involved. So what is in the pipeline? Throughout the world, several thousand GMO field tests have been conducted or are underway, again mostly in industrialised countries. Some 200 crops are currently under field testing in developing countries, the vast majority of these in Latin America (152) followed by Africa (33) and Asia (19). Many more countries than the seven that have already released GMOs are involved, and many more crop-trait combinations are being investigated, with greater focus on virus resistance, quality, and, in some cases, tolerance to abiotic stresses. It can therefore be expected that the number of GMOs ready for commercial release in these countries will expand considerably in the next few years, although many important crops – such as pulses, vegetables, and fodder and industrial crops and certain traits – such as drought and Aluminum tolerance – are still almost entirely neglected.

GMOs: where are we going?

So while the portfolio of GM applications is increasing in the near future, we need to deal rather rapidly with some overall questions to ensure that GM crops make an optimal contribution to world food security, food safety and quality, and sustainability and remain to the public at large. There are three big problems here. Firstly, directing genomics and related research to meeting these key challenges. Secondly, implementing international instruments and developing international standards of governance which ensure health and environmental safety, and so command public support. Thirdly, facilitating the access to research and new technologies for developing countries, poor producers and consumers. A related issue is that if developing countries are to be full partners in the international economy, they need assistance to build up their national legislation and regulations, as well as the relevant skills and infrastructures.

Directing research towards the key challenges

Are GMOs being directed to the right research priorities? Despite some hopeful signs, the inventory suggests that this is not yet the case. There are specific technical challenges that are difficult to handle through traditional crop-breeding, where transgenics may offer great possibilities for crops and forestry: these include drought and heat-tolerance; improved nutrient uptake and rooting; biological nitrogen fixation; responses to carbon dioxide; and tolerance to key abiotic stresses, such as salinity and drought. As part of a strategy of diet-diversification, genetic modification may help us address protein, vitamin and iron-deficiencies – see the famous example of the golden rice. Unfortunately, most of the traits needed are governed by multiple genes, and it will probably be some time before farmers and consumers benefit from such research.

The perceived profit potential of GMOs has already changed the direction of investment in research and development in both the public and private sectors away from systems-based approaches to pest management, and towards a greater reliance on monocultures with potentially adverse effects on landscape biodiversity. The possible long-term environmental costs of such strategies may be overlooked.

If research is to address the challenges of agriculture in the future, we need to put genetic modification in context, and realize that it is but one of the many elements of agricultural change. Scientists must not be blinded by the glamour of cutting-edge molecular science for its own sake. I am also worried about the disconnection between the laboratory and the field and the decline of agronomy as an integrative science. Governments need to be vigilant and not let this glamour, or the perception by private industry of major profit opportunities, draw investment away from research in other, more traditional fields such as water and soil management or ecology, and from public sector research. At the same time, the best science is developed in a climate of intellectual freedom without much direct government interference. It is a difficult balance to strike!

The cost of molecular technologies in plant breeding and the size of markets that are required to recoup the profits lead to the growing use of “hard” intellectual property rights over seeds and planting material and the tools of genetic engineering. This changes the relationship between the public and private sectors, to the detriment of the public sector. A policy question that governments must take up, in both the national and international contexts, is how to ensure that public research is not the “poor relation. In developing countries in particular, it is important for the public sector to retain enough capacity, resources and freedom of action to provide the services on which their national private sectors can build. They will also need to build their policy and regulatory capacities with regard to transgenic crops that originate elsewhere, and in this FAO has an “honest broker” role to play.

Thus we need a science that, in a globalized world, addresses local agriculture and local food security and helps to keep the rural areas liveable and attractive to young people in search of employment. The constraints to doing so are more economic than technical. Globalisation is not only a question of size, but also of kind: it is inextricably linked to privatisation, and major economic restructuring in both developed and developing countries has changed the balance of public and private sectors, and the privatisation of knowledge through intellectual property rights. This results in concentration, and there is often little economic incentive for global companies to address local needs. It has been estimated that the world’s top ten companies account for about 85% of the global market for the seed and agro-chemical industries. In 1998, just four companies controlled 69% of the seed market in the USA. Of course, globalization also promises to create opportunities for millions of farmers throughout the world, can offer opportunities to the poorer countries, and can drive rapid development and local capital accumulation. But it may also exacerbate existing differences among countries.

Developing transgenic crops implies massive investments, and the need for massive returns. The small number of GM technologies currently in use suggests that there is a real danger that the scale of the investment may lead to selective concentration on species and problems of global importance, and concomitant capital inertia. In this context, I must also sound a note of warning about the rising costs of regulation. In the health industry, where regulation is heaviest, bringing a pharmaceutical to market now costs about \$500 million; bringing a pesticide to market can cost about \$200 million; and it has recently been reported that a GM crop costs about \$30 million to produce, to which regulatory costs can add up to a further \$5-6 million. What crops can bear such costs in the commercial market? How are we to serve local needs, small farmers and poor consumers, and promote genetic and dietary diversity?

Developing agreed national and international instruments of governance

Most policy and regulatory activities regarding GMOs are national. International agreements have a role to play in harmonizing national regulatory systems, for example on transboundary questions, and when trade standards are involved. International agreements can also help governments, particularly the smaller governments, to rationalize their national capacities and investments through common action. In relation to GM crops, the major instruments concern risk-assessment and management in two areas: food and health; and the environment.

GMOs in food and agriculture have been around long enough for us to have some background against which to assess possible risks. There has been as yet no proven effect on human life. Moreover, a recent study of GMO releases into the environment in Britain showed that they had not survived in nature, as, in fact, they only would if they had an evolutionary advantage, which remains an important possibility. But let me say that state-of-the-art knowledge may not always be adequate to assess the risk of GMOs to health or the environment. Of course, lack of evidence of adverse effects is not the same as knowledge that genetic modification is safe.

In FAO we deal with environmental and food risk-assessment questions under a more general concept of "biosecurity", namely the application of sanitary and phytosanitary measures (SPS) and a methodology of risk analysis for food and agriculture, including fisheries and forestry. They include:

- the protection of animals or plants from pests, diseases, or disease-causing organisms;
- the protection of human or animal life from risks arising from additives, contaminants, residues toxins or disease-causing organisms in foods, beverages or feedstuffs;
- the protection of human life or health from risks arising from diseases carried by animals, plants or plant products, or from pests; and
- the prevention or limitation of other damage from pests.

Moreover, FAO has specific standard-setting responsibilities that relate directly to GMOs under the Technical Barriers to Trade (TBT) and the Sanitary and Phytosanitary (SPS) Agreements of the World Trade Organization.
There are several important international mechanisms in the context of GMOs.

Firstly, the Cartagena Protocol to the Convention on Biological Diversity, which was adopted in January 2000. It will come into force after fifty ratifications and is the main international agreement in relation to GMOs ("LMOs", or "Living Modified Organisms", in the language of the protocol). It covers the transboundary movement, transit, handling and use of all LMOs (except pharmaceuticals) that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health. It allows for standard-setting in relation to the handling, transport, packaging and identification of LMOs.

Secondly, food safety aspects of Genetically Modified Organisms are, at international level, dealt with by the FAO/WHO *Codex Alimentarius*, which covers all aspects of food safety. The *Codex* is currently working on standards for risk assessment for labelling, and for several other food safety aspects of GMOs. The *Codex* standards are recognized by the SPS and TLC Agreements.

Thirdly, the International Plant Protection Convention (IPPC) has the objective of preventing the spread and introduction of plant and plant product pests, including weeds and other species that have indirect effects on both wild and cultivated plants, and to promote appropriate control measures. This also applies to risks associated with LMOs. The IPPC sets International Standards for Phytosanitary Measures (ISPMs), which are also recognized in the SPS agreement. It is also in the process of establishing practical cooperation with the CBD and its Biosafety protocol. An IPPC expert working group met in September 2001, in coordination with experts from the CBD, to develop a detailed standard specification for an ISPM that identifies the plant pest risks associated with LMOs, and ways of assessing these risks.

Access and benefit-sharing

In a world governed by Intellectual Property Rights and concentrated research investments, genetic resources are the raw material to which biotechnology is applied: in agriculture, these are not wild products of nature, but the fruit selection and development by farmers throughout the world since the Neolithic. In contrast to other areas of industry, this poses the immediate question of how to guarantee continued access to those who have been involved before: the farmers and the breeders. Governments are now completing the negotiation, within FAO's Commission on Genetic Resources for Food and Agriculture, of a new, binding convention, the International Undertaking on Plant Genetic Resources, which we expect to be approved by our Conference in November. The Undertaking will create a Multilateral System of Facilitated Access and Benefit-sharing for the world's key crops. This is a major step, because dealing bilaterally with such widespread resources would involve unacceptably high transaction costs, and could impede agricultural progress. Multilateral access provides multilateral benefit-sharing, which includes the sharing of the benefits arising from the commercialization of materials from the Multilateral System through a mandatory payment.

The access of breeders to genetic material for further breeding– which becomes ever more difficult with GM crops under patents is a public good that needs to be protected. FAO is involved in several instances, such as in the World Intellectual Property Organisation, where concerns of food and agriculture and IPRs are being discussed.

GMOs and scientific responsibility

Science never took place in a vacuum, but now more than ever, it needs to stand up to public scrutiny, to engage with public opinion, and address technical and ethical issues in the application of science to the needs of the poor. The current debate over transgenics and the labelling of foods containing ingredients from GMOs has highlighted the need for transparency. There is growing awareness of the public's ambivalence towards genetic engineering and its aims. The research sector should advertise the fact that it disposes of an important instrument for quality control. The scrupulous honesty of the peer review process, under the watchful eye of scientific institutions, including scientific academies, the great journals, is a guarantee for quality, if not always for relevance The food and agriculture sector could well take the example of the declaration last week by twelve of the world's most prominent medical journals of a policy to prevent the corporate sponsors of research exercising control over the analysis, interpretation and reporting of research results. However, the general public is largely unaware of peer reviews and standard setting (which takes place through similar processes) and public trust remains low.

Conclusion

Genetic modification has increased production in some crops. But the evidence we have suggests that the technology has so far addressed too few challenges, in few crops of relevance to production systems in many developing countries. Even in developed countries, a lack of perceived benefits for consumers, and uncertainty about their safety, have limited their adoption. The scale of investment involved, and the attraction of advanced science, may distort research priorities and investment. Genetic modification is not a good in itself, but a tool integrated into a wider research agenda, where public and private science can balance each other. Most of the short term successes may be derived from marker assisted breeding and diagnostics rather than from transgenic crops per se.

Steering research in the right direction and developing adequate and international agreements on safety and access is a difficult and responsible task. While we are more aware than ever of the need to manage international public goods responsibly, the political tools to do so are weak, and, in a globalised economy, the voices of small countries and poor producers and consumers often go unheard. I believe that scientists have moral responsibilities to speak for the weaker segments of society, because they sometimes best understand the likely results of not doing so.

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[i] In the preparation of this text, special thanks go to Clive Stannard, and the contributions of Jim Dargie, Niek van der Graaff and Andrea Sonnino are gratefully acknowledged.