Genetically modified organisms and their critics

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Note. This paper was prepared as an NRP at the end of the 1990s for the Overseas Development Institute, but they lost their nerve when it came to publishing. It hasn't been updated, but I think it is still useful.

The potential benefits of genetically modified organisms (GMOs) used for food purposes include reduced costs of production, reduced use of agro-chemicals and increased shelf life. In view of the novelty of these constructs, there are numerous unresolved scientific issues about their safety, their impact on the environment etc. In addition, the drawbacks include significant and potentially disastrous reduction in food security in the developing world. The agenda for the debate over genetically modified organisms is dominated by multinational companies with vested interests in the successful marketing of these products, although research is conducted by a wide rage of institutions. However, they are now opposed by a coalition pressure groups, some of whom favour direct action and others putting forward crypto-religious objections which may act to undermine legitimate scientific concerns and the debate has thus become polarised. The major issue for developing countries is food security; claims that GMOs will address world hunger are distinctly spurious. The impact of a radical shift in crop ecology is greater in less developed countries where loss of a crop can lead to disaster.

1. Companies involved in the production and sale of Genetically Modified Organisms (GMOs) have recently commissioned expensive advertising campaigns to promote their virtues. Fear of GMOs is portrayed as 'anti-scientific' or deriving from a quasi-religious motivation.
2. There has been considerable public concern in Europe about the potential impact of GMOs and they have received a generally negative press. Anarchist groups have begun to raid farmers' field trials causing extensive disruption. Their concern may or may not be well-founded but undoubtedly the next few years will see extensive and destructive popular protest throughout the developed world.
3. A likely response by the large companies, as with tobacco, will be to promote these products in developing countries where controls are laxer and understanding of the scientific issues involved less-diffused.
4. The literature displays a certain confusion between the possible dangers of *consumption* of GMOs and the likely consequences of their *production*, which is framed by a socio-economic context.
5. The evaluation of the safety of GMOs is taking place within the framework of 'ordinary' toxicity testing which is virtually irrelevant to their claimed effects. Existing assurances that products have been tested and 'proven' safe are thus of absolutely no value.
6. Both the scientific issues, and socio-economic concerns to do with equity suggest that wider debate and greater public understanding is essential.

'I'm absolutely appalled that these trials are being used to say food is either harmful or safe. To conduct tests on humans would take 30-40 years. By then, patents, which last 22 years, would have expired. It wouldn't be economic. The rat trials are rigged to support commercial infrastructure.'

Richard Lacey
University of Leeds
Observer, 16/8/98

Recent widespread publicity concerning GMOs, as well as extensive advertising by companies with an interest in launching these on the market has accelerated public concern about their impact. Supposedly independent institutes, heavily funded by these companies, have been promoting GMOs while glossing over very real concerns, both scientific and socio-economic. However, public concern has pressured the British Government into considering a three-year moratorium on GMOs, which the major companies in this field are pledged to oppose through the EC.

The discussion paper[1] presents and evaluates major arguments as well as drawing out the relevant policy conclusions. The literature displays a certain confusion between the possible dangers of *consumption* of GMOs and the likely consequences of their *production*. This tends to favour the producers since it is in fact most unlikely that these products will demonstrate any short-term toxicity. The issues now associated with GMOs are effects of long-term consumption of GMOs and the effect that the biotechnology industry is likely to have on biodiversity.

What are GMOs and why are they relevant?

Genetically modified organisms (GMOs) are theoretically any organism, but particularly plants, where genes from an external source have been inserted into the germplasm of that organism. The usual function of this is to make the organism resistant to pathogens, insect pests or chemicals as part of agro-industrial production. Extensions of these principles are easily foreseeable for livestock, and thence to semi-domestic organisms such as forest trees or wildlife in game parks. Typically, if a crop is made resistant to a specific herbicide then the field can be sprayed at any time, killing the 'weeds' and thereby increasing crop yields. A good example is glufosinate-resistant oilseed rape. Glufosinate is a non-selective herbicide manufactured by Hoechst which is toxic for humans and animals (Cox 1996). If farmers buy GM seeds then considerable increases in

- Food security is seriously compromised by a reduction in genetic and species diversity as different production methods are needed for different environments.
- Reliance on a smaller gene base undermines resistance to disease.
- The production of terminator genes, and the tying of resistance to own-brand herbicide increases farmers' dependence on seed producers.
- Neither producers nor consumers know the extent or the nature of the risks involved in genetic modification.
- Biodiversity is threatened by the production races; this can lead to permanent losses to ecosystems.
- The benefits of the production methods accrue to the producers rather than to the consumers; consumer safety is not understood, and cannot be factored into the equation of efficiency.
- Developed countries have shown considerable resistance to genetically modified organisms.

[1] Thanks to Rob Tripp and Mark Thomas for their comments on an initial version and some of the examples used in the text.

glufosinate use can be forecast. Farmers in India pay a "technical fee" of $50-$60 per acre for Monsanto's genetically engineered seeds, and are required to sign a contract saying that they will not buy chemicals from anyone else.

The debate has been largely played out in the developed world at present, through blanket advertising from one of the companies involved (Monsanto) opposed by a coalition of media-savvy protest groups through television, radio and the World-Wide-Web. Moreover, the majority of crops planted are so far in developed countries, notably the USA and UK, although countries such as India and Brazil are developing their own programmes. However, it would be misleading to think this is only an issue for the developed world. The GMO companies, facing bad publicity and suspicion in the developed world are likely to target less-developed economies, where regulatory frameworks are still in their infancy, as have the tobacco companies faced with similar legal and image problems. Developing world programmes, usually funded by central government, will inevitably be non-transparent. As it happens, GMOs have substantial implications for food security issues relating to the presence of wild relatives of staple crops in developing countries and this paper pays particular attention to these issues.

2. Who is promoting GMOs?

GMOs are essentially being promoted by large chemical companies, the most important and high-profile of which are Monsanto, based in St. Louis, Pioneer Hi-Bred International (a seed company part-owned by Dupont), Novartis and Ciba-Geigy, Switzerland. The most economically significant GMOs are those that function in relation to a specific chemical manufactured by the same company, with the exception of insect-resistant types which may ultimately displace chemicals. Research is also being conducted in University Departments and CGIAR centres.

All the major companies in the GM business have recently formed a coalition, EuropaBio, with sponsorship from the Dutch government, to protect their interests. Rather tactlessly, they have chosen to use the same public relations company that wrote press releases for Union Carbide after the Bhopal disaster. As more and more European countries raise objections to the unfettered spread of GM organisms, the companies are becoming concerned. They have considerable political muscle in the United States, and have recently written to President Clinton urging him to threaten the EU with WTO trade sanctions for not opening up the European market to GM crops. The letter notes that these objections are not based on science but ‘emotion which often turns to pure hyperbole’ and that ‘segregation of bulk commodities is not scientifically justified and is economically unrealistic’.

It is reasonable to assume that trans-national and multi-national companies will be interested in the profitability of their products. Their GMOs are designed to provide a return for shareholders, not improve the welfare of farmers. The environmental record of biotechnology companies does not recommend them, with Monsanto being responsible for 5% of the toxic chemicals released into the US environment in 1992 (http://www.geocities.com/Athens/1527/ge/feedWorld.html). Developing countries and particularly the marginalised groups within them do not have access to the technologies or resources to compete with large northern companies, and this is likely to lead to greater disparity in the clout that producers in the north and those in the south can command in the global market.

3. Who is opposing GMOs?

Opposition to GMOs has brought together a wide coalition of groups, which would be somewhat improbable partners in other areas of civil society. One element is the anarchist groups allied to the 'road-protesters', dedicated to opposition to GMOs for ill-dissected but perhaps quasi-religious motives. These are linked to the genteel spirits of English Nature, fretting about the disappearance of the corn-bunting from our fields and to a more generally concerned public who read Greenpeace statements, nervous of the speed of scientific change around them. GMOs then become somehow entangled with computers, embryo technology and the deep-seated fears of tampering with 'life' that have long been a staple of science fiction.

A problem with much of this is that it has a spiritual element, drawing on the belief that GMOs are 'against nature'. The companies have not been slow to identify this as non-scientific and to use it as a tool to condemn these groups. This may be bad strategy on their part: opposition may not always be well-founded scientifically but it can still fuel extensive popular protest in the developed world. Nonetheless, such opposition is a poor foundation for a clear-eyed analysis of the problems associated with GMOs, however much we may respond to it viscerally.

A poll in the US found that 93% of consumers were in favour of labelling food containing genetically modified organisms (http://www.greenpeace.org/~usa/reports/biodiversity/sayno.html), and similar figures have been recorded in Europe. Large food manufacturers and distributors have taken a stance against the use of GMOs in food products. Unilever, Kraft Jacobs Suchard and Nestle have all decided against using GE soya, until further information is available. Supermarket chains have made various policies, including complete bans on GMOs and labelling of products which have been modified; consumers claim they are willing to pay more for products which do not contain GE crops.

4. The scientific arguments

4.1 Do GMOs work?

The impact of GMOs is hard to establish because of the nature of comparisons. For example, Monsanto's own figures for 'Roundup Ready' soybeans show only a 9% increase in weed control. It is clear that increases in productivity are not always as striking as initially claimed. Nonetheless, the operational test is whether commercial farmers lay out money for them and in some cases they clearly do: demand for DeKalb maize seed was so high that additional fields were established in Chile and Argentina and the seed air-freighted to Miami.

One source of disappointing results may be that protecting a plant against one type of pathogen may simply leave it available for attack by another species. This is an endless ladder; pathogens that are at present subclinical may become economically significant as soon as their competitors are eliminated. As soon as a gene for resistance to one pathogen is inserted, another one will arise to take its place. This process, of course is not confined to GMOs; breeding wheats for rust resistance is a continuous process, plant breeders are constantly trying to outrun the pathogen's natural inventiveness. This is speculation, however, since the technology is still in its infancy. It is likely that the gene splicers will find ways to improve their coverage, rather like developing broad-spectrum antibiotics. Certainly, limited improvements in productivity should not be the basis for any argument against GMOs since it is likely to be rapidly overtaken by history.

4.2 Whose science?

One of the constantly troubling aspects of the approval of 'Novel Foods and Processes' for outsiders is that the data by which committees judge food safety is largely supplied by the industry or by institutes, which, although nominally independent, are funded by grants from these same industries. The guarantee of quality is supposed to be provided by the independent refereeing of the journals in which this science is published. There is, however, a logical gap at this point. Referees, assuming they don't work for similar institutes locked into the same cycle of grant applications, can only assure editors that correct procedures appear to have been followed. Selectivity in topics, data and statistical method can contribute powerfully to the 'right' result, as far as the GMO companies are concerned. This is far from the fantasy of paranoia: the sorry and documented history of the suppression of research tending to show links between industry ruminant food rendering practice and BSE in cattle illustrates neatly these processes at work. Indeed the lethargic response of these committees in the case of BSE may have much to do with general levels of public distrust of licensing procedures.

4.3 The transfer of genes from GMOs to close biological relatives

A problems for conventional plant breeders is the transfer of genes between experimental crops in a field and its wild relatives beyond the fence. The pollen of sexually reproducing plants can be blown long distances in some cases. Some families are more susceptible than others: the Cruciferae, which include the Brassicas (cabbages etc.) are particularly prone to this type of promiscuity. Recent research on transgenic oilseed rape has shown that it will cross-breed with its weedy relatives, making them similarly resistant to herbicides (Mikkleson *et al.* 1996). This may result in the genesis of 'superweeds' which could require even more toxic chemicals to eliminate them. As AgrEvo, a company marketing transgenic rape seeds, observes '*the farmer can always control these resistant weeds with other products*' (http://www.agrevo.com/biotech/QA).

In many parts of West Africa, the wild relatives of sorghum and millet cross constantly with their domesticated relatives, and the crosses invade the field as weeds and constitute a significant economic problem. The same is true of Eurasian rices and foxtail millet in China. The transfer of genes from GMOs to close relatives, risks creating virtually ineradicable weeds and eliminating the 'normal' gene pool of such wild plants. This would be a major contribution to food insecurity in developing countries, if ineradicable weedy varieties of major food crops such as sorghum and millet were created.

4.4 Is gene transfer like cross-breeding?

A common argument is that gene transfer is simply a modern form of cross-breeding, accelerating a process that historically has taken centuries or millennia. This is seductive but false. Organisms evolve species barriers, probably as a mechanism against pathogen transfer, and cross-breeding to produce fertile offspring can take place only between closely related organisms. However, gene-splicing conjoins anything: in a famously bizarre example, genes from arctic fish are being spliced into strawberries, to help them resist frost. This circumvention of natural species barriers is unlike any other natural or anthropic process and its consequences not predictable from existing experimental data. Whether it is true that 'the introduced gene randomly incorporates itself into the DNA of its new plant or animal host' remains to be seen.

In another development, soil rhizobia are now being genetically modified to produce additional nitrogen. *Rhizobium meliloti* has been spliced to be resistant to antibiotics and to fix up to three times as much nitrogen as 'normal'. The benefits are that this should increase soil fertility without chemical fertiliser. The downside is that such a rhizobium would be quite untrackable. Once released it could never be recalled. The effects on soil ecology are difficult to predict.

4.5 Transfer to other parts of the food chain

The single most important question on which scientists are divided is the relative stability of chromosomes. Bacilli such as *Bacillus thuringensis* (Bt) (a close relative of anthrax) has been used as a dusting powder insecticide on cotton and cereal crops for a long period and has appeared to be safe. Novartis has inserted the relevant gene into maize to kill insect pests, such as springtails, directly and this maize has been released on the European market. The potential to insert it into the DNA of these plants so that it codes directly for toxins is problematic. If it is proved unstable it could begin to produce toxins of unknown but potentially worrying categories.

Another unexpected consequence was that it has begun to kill predatory insects that consume insects that have fed on Novartis maize (http://greenpeace.org.pressreleases/geneng/1998apr23.html). Novartis apparently knew of research to this effect when submitting its dossier for EU approval but somehow apparently omitted the relevant papers. However, this has been independently demonstrated again (Environmental Entomology ref.). Predatory insects are essential to ecology of crop production, and their disappearance may lead to population explosions of other species present now at only sub-economic levels of significance.

A separate concern that has been raised is the transmission of novel genes via honey-bees. Since honey-bees carry pollen between plants and in particular between the field and the wild landscape, might they not be responsible for spreading novel genes unpredictably to other plants in the food chain? A study of the DNA of pollen in honey has shown that it can remain viable for up to seven weeks after being taken from the plant (Eady *et al*. 1995).

4.6 Antibiotic markers

An ancillary concern is the use of antibiotic genes as 'markers' for the gene-spliced products of a particular company. These have no function in themselves except for trial purposes, but there is some concern that these will create antibiotic resistance in organisms to which they spread. It is at least a possibility that resistance to the antibiotic ampicillin could be transmitted to humans via corn and beef cattle (http://www.geocites.com/Athens/1527/recipe.html). Certainly DNA fragments can survive digestion and enter the bloodstream of mice (Shubbert *et al.* 1996). Presumably they may be able to create antibiotic resistance in organisms which ingest them.

4.7 Impact on agrobiodiversity

One objection lodged against GM field crops is that they will lead to an increased use of broad-spectrum agro-chemicals, thereby both increasing soil contamination and reducing the diversity of other species in the field. Herbicides tend to be species-specific which is less threatening to agrobiodiversity, but if there is no danger of affecting the crop in the field, farmers will increase

application of broad-spectrum herbicides. This in turn will reduce the habitat for typical wild species such as birds adapted to cornfields that have co-evolved with 'traditional' crop varieties.

While it is certainly true that the cereal fields shelter 'wild' organisms, it is somewhat strange to argue that farmers should favour this. Farmers want to maximise yield and if they can rid crops of potential competitors such as weeds then it would be perverse to expect them not to do so. There is little doubt that the decline of many 'traditional' cornfield species over the last thirty years is connected to more effective farming and thus elimination of habitats. GMOs or no, it is unlikely that farmers will want to reverse these trends.

There is a surprising relevance to the elimination of weeds outside the farming systems of the developed world. Although farming is generally considered to be a sort of policing exercise in intensive systems, in many tropical farming systems, weeds are integral to overall productivity. 'Tolerated weeds' are often pantropical potherbs are thus retained in the field for consumption (Blench 1997). Similarly, invasive species such as cane-rats, which would be considered pests on crops in Western farming are 'harvested' through hunting. Eliminating agrobiodiversity in some tropical farming systems will only reduce levels of food security. Farmers in developing countries have always maintained a healthy scepticism about conventional herbicides for these very reasons.

A diversity of breeds and species is essential to subsistence farming methods. Changing environmental conditions render different crops more productive; subsistence farmers in developing countries are, in the main, more susceptible to changing conditions as there are fewer buffers in the form of irrigation schemes and fertilisers to protect crops from the vagaries of the weather and disease. Although the importance of biodiversity as a coping mechanism is being recognised in arable farming, efforts to protect and strengthen biodiversity are directly undercut by the promotion of cloned and genetically modified organisms. The EU patent directive for biotechnology contravenes the international convention on biological diversity, according to Greenpeace (http://www.greenpeace.org.pressreleases/geneng/1998may12.html).

5. Arguments from social equity

5.1 Feeding the world

One of the more ingenuous claims made by the biotechnology companies is that as the world's population increases new technologies are required to feed the growing hungry masses. In their publicity, only GMOs can solve this problem. However, as social and political theorists never tire of pointing out, the problem with world food deficits is not a lack of food but that the food is not in the right place at the right time. Indeed most of the food problems in the world are the fairly direct result either of conflict or of extreme climatic events, neither of which, unless the companies are cleverer than we think, are within the province of gene-splicing to resolve.

5.2 'Terminator' genes

The concept of a 'terminator' gene is one that will cause the seed to become sterile at the end of the growing season, so it effectively cannot be replanted for the following year. The advantage to the company is that farmers are compelled to buy the seeds every year. What is perhaps more surprising is that these genes have been developed with US government money for the commercial advantage of large corporations.

Since farmers in developed economies quite often buy seed every year and indeed where hybrid maizes are grown, this is inevitable, this may sound like an extension of an existing principle. However, in principle hybrid maize seed can be collected and replanted, and farmers in developing countries where supplies and infrastructure are unstable may resort to this as an insurance policy. Distributing 'terminator' seed in such developing countries is therefore likely to increase food insecurity.

6. The GMO debate as theatre

Recent events have made it clear that the debate over GMOs is only partly being played out in the scientific arena. It is also partly a symbolic combat, pitting a public made suspicious of rapidly evolving science by such fiascos as the BSE saga against the resources of powerful multinationals who have previously played only to audiences of readers of Nature, but who must now market themselves with the expertise and finesse of Coca-Cola. Large corporations like Monsanto or Dupont clearly have a major image problem, in that for years they have produced chemicals to support genetically uniform, non-sustainable agriculture and have indeed been held responsible for significant amounts of industrial pollution. It therefore rather strains credibility to assume that they have suddenly been converted to 'green' practices and sustainable agriculture. Road protesters, themselves no strangers to effective publicity, having 'won' a number of significant battles for SSIs announced that GMOs would be their next target and indeed have already 'hit' a number of field trials.

Recently, the announcement on television that mice fed on GM potatoes showed significant immune-system problems was rapidly followed by the forced retirement of the scientist in question, who appeared to have made some elementary errors of procedure. This allowed representatives of the GM companies to appear on television, claiming that this 'showed' GMOs were safe and that it was a 'triumph for science'. These claims are as much nonsense as the brouhaha that preceded them but in the overheated atmosphere presently prevailing, they were not immediately challenged.

The issue will not disappear soon, since the opposing forces are only beginning to consolidate their resources. Moreover, since only a little speculation about what may be possible with gene-splicing technology rapidly crosses over into science fiction, an accelerating cycle of scientific/ethical issues is likely to reinforce the debate at regular intervals.

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