technological fix. However, by selling GE foods as a panacea to political and social problems, governments and industry may be able to avoid difficult questions while large multinational corporations can look forward to a prosperous future. The promotion of genetic engineering as an essential prerequisite to feed the world of the future is therefore little more than a smokescreen to drive acceptance of the technology in the developed world and the global aspirations of the companies involved.

## References


1 See e.g. Monsanto's advertisement in The Observer, 2nd August 1998, 'Worrying about starving future generations won't feed them. Food biotechnology will.'
2 Kendall, H.W., Beachy, R., Eisner, T., Gould, F., Herdt, R., Raven, P.H., Schell, J.S. & Swaminathan, M.S. (1997) Bioengineering of crops: report of the World Bank Panel on Transgenic Crops. International Bank for Reconstruction and Development/World Bank: Washington DC.
3 Vasil, I.K. (1998) Biotechnology and food security for the 21st century: a real-world perspective. Nature Biotechnology 16: 399-400.
4 Monsanto (1997) Report on Sustainable Development including Environmental, Safety and Health Performance. Monsanto: Missouri.
5 Biotechnology and Biological Sciences Research Council Annual Report 1996-97. BBSRC: Swindon.
6 FACTT: A project to promote Familiarisation with and Acceptance of Crops incorporating Transgenic Technologies in modern agriculture. A demonstration project under Framework Programme IV – European Commission. Paper OCS 8/96, Annex D & Draft Technical Annex – December 19 1995.
7 Monsanto Company 1997 Annual Report.
8 Beringer, J. (1994) Are there unresolved issues regarding the possible generation of new viral pathogens from transgenic plants? Proceedings of the 3rd International Symposium on The Biosafety of Field Tests of Genetically Modified Plants and Microorganisms. November 13-16 1994, Monterey, California.
9 Rissler, J. & Mellon, M. (1996) The Ecological Risks of Engineered Crops. MIT Press: Cambridge MA.
10 Puonti-Kaerlas, J. (1998) Cassava Biotechnology. Biotechnology and Genetic Engineering Reviews 15: 329-364.
11 The Gene Exchange. Summer 1998. Union of Concerned Scientists: Washington DC.
12 RAFI News Release 13 March 1998. Biotech activists oppose the "terminator technology". New patent aims to prevent farmers from saving seed.
13 Mooney, P.R. (1996) The Parts of Life. Agricultural biodiversity, indigenous knowledge and the role of the third system. Development Dialogue Special Issue 1996: 1-2.
14 Patenting, piracy and perverted promises. Patenting life: the last assault on the commons. Genetic Resources International: Barcelona (undated).
15 Information from various briefings prepared by RAFI International, Ottowa, Canada.
16 India to challenge Basmati rice 'invention'. Nature 391: 728, 19 February 1998.
17 GeneWatch (1998) Genetically engineered oilseed rape: agricultural saviour or new form of pollution? GeneWatch: Litton, Buxton, UK.
18 Bunders, J.F.G. (1990) Biotechnology for small-scale farmers in developing countries. Analysis and assessment procedures. VU University Press: Amsterdam.
19 Buttel, F.H. (1997) Some observations on agro-food change and the future of agricultural sustainability movements. In '*Globalising Food. Agrarian questions and global restructuring*' D Goodman & M.J. Watts (eds) Routledge: London.
20 Monsanto (1998) Background. The Roundup Ready soyabean system: sustainability and herbicide use. 11pp
21 Pretty, J..N. (1995) Regenerating Agriculture. Earthscan: London.


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# GENETIC ENGINEERING:

## Can it Feed the World?

GeneWatch


**Briefing Number 3**
**August 1998**


**This briefing examines how genetically engineered foods are being promoted as essential to feeding the world's growing population and discusses whether such claims are valid.**

The proponents of genetically engineered (GE) foods argue that biotechnology is essential to feed the world's growing population and build a sustainable agricultural system[1]. The population, which is currently 5.8 billion, is expected to reach 8 billion by 2020 and 11 billion by 2050[2,3]. The advocates of genetic engineering believe that the increasing demand for food must be met without expanding the amount of land used for agricultural purposes (to protect biodiversity) and by addressing issues of soil erosion, salinisation, overgrazing and pollution of water supplies[3,4]. However, many organisations in less developed countries, aid agencies and environmental groups are less positive about the role genetic engineering can play in solving problems of hunger and tackling environmental degradation.

### Who Is Behind GE Foods?

The development of GE foods is not being driven by farmers, consumers or less-developed countries but by large multinational chemical companies who have recognised a business opportunity. Six major companies now dominate the production of GE foods worldwide: Monsanto, DuPont, Hoechst, Novartis, Rhône Poulenc and Zeneca. These now style themselves as the 'Life Sciences' industry with activities which may span food, food additives and pharmaceuticals as well as their more traditional roles of chemical and pesticide production.

Governments of developed countries are also supporting the introduction of GE foods. In 1994, the Biotechnology and Biological Science Research Council (BBSRC) was formed to replace the Agriculture and Food Research Council in Britain, reflecting a change in emphasis in agricultural research. Many representatives of large corporations sit on Research and Strategy Boards of the BBSRC[5], giving them the ability to influence the research programme. In sharp contrast, consumer and public interest groups (other than the Country Landowners' Association) are given no such opportunity for input.

The European Commission also finances the promotion of GE crops and foods. For example, they have granted £1 million to the so-called 'FACTT' project[6], with a similar amount being contributed by Hoechst and other partners. In effect, the project has become a sales promotion for the GE oilseed rape developed by Hoechst subsidiaries AgrEvo and Plant Genetic Systems to bring about *".. the creation of familiarity with and acceptance of transgenic crops for farmers, extension organisations, processing industry, regulatory organisations, consumer groups and public interest groups"*.[6]

### What GE Foods Are Being Developed?

Looking at the products which are being developed should give some clues as to their role in meeting global food needs. The United States leads the world in the commercialisation of GE crops and clearly illustrates the direction research and development (R&D) is taking (see Box 1).

*The development of GE foods is being driven by large multinational chemical companies.*

*The strategy behind GE foods has been primarily to identify characteristics with quick payback.*

| Crop | Modification | Company | Applications |
|---|---|---|---|
| **Oilseed rape** | High lauric acid | Monsanto/Calgene | Soap and processed food production |
| | Herbicide resistance - glyphosate | Monsanto | Weed control |
| | Herbicide resistance - glufosinate | AgrEvo | Weed control |
| | Fertility control system | Plant Genetic Systems | Hybrid seed production |
| **Chicory** | Fertility control system | Plant Genetic Systems | Fertility control system |
| **Maize** | Insect resistance - Bt toxin | Monsanto (3); Novartis (2); Mycogen | Insect control |
| | Herbicide resistance - glyphosate | Monsanto (2) | Weed control |
| | Herbicide resistance - glufosinate | Monsanto; Hoeschst | Weed control |
| | Fertility control system | Hoechst/AgrEvo/Plant Genetic Systems | Hybrid seed production |
| **Cotton** | Herbicide resistance - bromoxynil | Monsanto/Calgene/ Rhone Poulenc | Weed control |
| | Herbicide resistance - sulphonyl urea | DuPont | Weed control |
| | Herbicide resistance - glyphosate | Monsanto | Weed control |
| | Herbicide resistance -bromoxynil Insect resistance - Bt toxin | Monsanto/Calgene/ Rhone Poulenc | Weed and insect control |
| **Papaya** | Virus resistance | Hawaii & Cornell Universities | Viral disease control |
| **Potato** | Insect resistance - Bt toxin | Monsanto | Insect control |
| **Soybean** | Herbicide resistance - glyphosate | Monsanto | Weed control |
| | Herbicide resistance - glufosinate | Hoechst/AgrEvo | Weed control |
| | High oleic acid | DuPont | Increase stability. Reduced polyunsaturated fatty acids |
| **Squash** | Virus resistance | Seminis Vegetable Seeds (2) | Protection against disease |
| **Tomato** | Delayed ripening | Agritope; Monsanto/Calgene; DNA Plant Technology; Monsanto | Increase fresh market value |
| | Altered softening | Zeneca | Increase processing value |

**Box 1: GE crops commercialised in the USA – July 1998[11].**
Figures in brackets show the total number of varieties of the crop with a particular type of modification produced by any one company.

The strategy behind GE foods has been primarily to identify characteristics with quick payback such as herbicide resistance. Both Monsanto and AgrEvo will be



management. They are most successful in complex and varied agricultural systems and yields can be increased dramatically. In sustainable agriculture projects in Honduras, maize yields have been increased by 300%; in India, yields of millet have been increased by up to 154%; in Burkina Faso, sorghum and millet yields increased by 275% (see Ref 21 for details of these and many other case studies). These are real, tangible benefits for people now, not PR promises for the future.

Following a comprehensive study of sustainable, low input systems around the world, Jules Pretty of the International Institute of Environment and Development has concluded[21] that introducing such systems would lead to:

"• *Stabilised or lower yields in industrialised countries, coupled with substantial environmental improvements;*
• *Stabilised or slightly higher yields in Green Revolution lands, with environmental benefits;*
• *Substantially increased agricultural yields in complex and diverse lands based mostly on available or local resources."*

*In contrast to genetic engineering, alternative approaches to agriculture have been starved of resources and research.*

One of the striking points about these conclusions is that the greatest yield improvements would occur in areas where modern agricultural methods have not yet been introduced, where population increase may be greatest, and where farmers are least likely to be able to afford high input systems. Another important aspect of low input systems is that they tend to be specific to the local conditions, not amenable to globalisation and unprofitable for large corporations. Control is exercised, and benefits felt, at a local level.

However, despite their clear advantages, and in contrast to the promotion of genetic engineering, these alternative approaches to agriculture have been starved of resources and research.

## Conclusions

Although global food production has increased over the past three decades, the benefits have not been evenly reaped. In 1994, food production could have supplied 6.4 billion people (more than the actual population) with an adequate 2,350 calories per day, yet more than 1 billion people do not get enough to eat[2].

*Genetic engineering looks set to perpetuate and intensify many of the problems which have led to present day food insecurity.*

Modern agricultural systems have caused serious environmental damage, including pollution and health problems through the use of large amounts of chemical inputs, and the erosion of genetic diversity through reliance on a small number of crops and varieties. Small farmers in less developed countries, unable to afford the expensive inputs of intensive agricultural systems, have been prevented from competing with cheap imports and their livelihoods have been placed at risk. National debt burdens have forced poor countries to focus on cash crops, not staple foods. Genetic engineering looks set to perpetuate and intensify many of the problems which have led to present day food insecurity. Corporate control, products designed for a developed world market, packages of expensive seed and inputs coupled with the potential for further environmental harm as a result of genetic pollution mean any benefits will remain concentrated in developed nations. The complex issues surrounding food provision are unlikely to be solved by a new them to survive in conditions where they would normally have been unable to do so. Such problems may be even more acute in tropical countries where the majority of the major food crops evolved and related wild species abound.

Furthermore, the analysis expounded by many of those promoting genetic engineering for its ability to feed the world does not address many of the long-term issues nor the seemingly intractable problems and contradictions of today. For example, the problems of agricultural production in Africa have simply been attributed to *"inefficient agricultural systems"* which can be solved by the faster introduction of modern agricultural methods[3]. Such a simplistic dismissal of the problems of food production in Africa such as poverty, war and unpredictable rainfall to sell technological solutions seems cynical in the extreme. It also ignores some of the problems associated with the introduction of modern agriculture.

> *"On the basis of experiences with earlier efforts to introduce Western agricultural innovations in developing countries, it can be expected that innovations resulting from such a [biotechnology] focus will lead to a decrease of commodity prices and result in a greater instability of the agricultural structure in many developing countries. These developments may lead to a further marginalization of small-scale farmers and to an accelerated migration to the already over crowded cities, where job opportunities are very limited."* [18]

***Focusing on a technology rather than the underlying causes of hunger may exacerbate the situation.***

This statement comes from a 1990 study which considered the complex nature of agricultural systems in developing countries and the role biotechnology, including genetic engineering, could play. Crucially, it indicates that focusing on a technology rather than the underlying causes of hunger or inability to increase food supplies may exacerbate rather than improve the situation.

A farming system which relied on GE crops could, like other intensive systems, result in short-term yield increases but simultaneously degrade the underlying ecosystems[19]. The yield of Roundup Ready soybeans in the US was apparently 5% higher on average in 1996 and 1997 than that of conventionally bred varieties[20]. However, not all farmers have had positive experiences with GE crops [11]. For instance, the Mississippi Seed Arbitration Council has ruled that Monsanto's GE Roundup Ready cotton failed to perform as advertised last year and recommended that nearly $2 million be paid to three farmers who had large losses. In Arkansas last year, farms growing GE insect resistant cotton had, on average, lower yields than conventional varieties and crops had to be harvested twice rather than once.

## Is There An Alternative To Genetic Engineering?

There are alternative systems which could provide food security and increase food production in the future if they were coupled with mechanisms to address inequalities in food supply. Systems which do not involve high levels of input are already widely used, are becoming more sophisticated and can be as productive as high input systems, although they will have differential impacts depending on the part of the world in which they are applied. They also have the added advantage of bringing environmental benefits. These approaches focus on soil, water and nutrient conservation, green manures, raised fields, terracing and integrated pest



able to increase sales of their herbicides (glyphosate and glufosinate respectively) by selling their herbicide resistant crops to farmers and tying them in to using their own brands of herbicide. Monsanto's sales of glyphosate have already risen as a result of the introduction of GE Roundup Ready crops in the United States[7]. GE crops with insect resistance and prolonged shelf life have also been included in the first wave of commercialisation.

Disease resistance forms the next major class of GE crops in the R&D phase. Most of the virus disease resistance involves using genes from the virus itself to induce resistance in the crops. The mechanisms which underlie this are poorly understood and concerns have been raised that recombinations with other viruses may lead to the production of new strains of disease-causing viruses[8].

***There is virtually nothing that is directly relevant to less developed countries.***

Also in R&D are more herbicide and insect resistant crops and crops with improved characteristics for processing, such as oils with higher concentrations of certain fatty acids and wheat with modified starch content to aid in bread making. Other aims are to improve shelf lives of a wider range of fruits and to make crops resistant to frost and drought. Improving nutritional content is also proposed.

What is noticeable about these developments is that they are mainly being applied to crops of importance to the developed world and fit *"comfortably into modern foods systems that emphasise food processing, consumer niche markets and production efficiency"*[9]. There is virtually nothing that is directly relevant to less developed countries and internationally there are just four *"coherent, coordinated"* GE research programmes on Third World crops[2]. Even these are minimally resourced.[10]

The World Bank Panel on Transgenic Crops concluded that technology transfer projects between multinational corporations and less developed countries were so rare that the examples they cited were *"exceptional"*[2]. At best, therefore, it seems that applications to such countries will be largely incidental, arising from so-called *"spillover innovations"*.[2]

## How Is The Market For GE Foods Being Established?

'Life sciences' companies are building large international networks to market their GE crops throughout the world. Monsanto in particular have adopted an extremely aggressive take-over policy in recent years, systematically acquiring seed companies, small cutting edge biotechnology firms and companies holding important genetic resources (see Box 2). Together with strategic agreements to market seeds worldwide, this has established Monsanto in the forefront of GE crop supply and they now dominate the maize, cotton and soybean markets. In their own words, *"The opportunity to expand geographically is creating exponential growth potential for existing products"*.[7]

***40% of the world's commercial seed trade is now owned by just ten companies.***

Monsanto and other 'life sciences' companies' control over the world's commercial seed trade means that 40% of this trade is now owned by just ten companies. This market dominance is reinforced through patenting genetic material. Monsanto, for example, have made sweeping patent claims to all GE cotton (US 5,159,135; EP 270355) and brassicas (US 5,188,958; EP 270615; WO 8707299).

*Patenting is highly detrimental to small-scale farmers.*

**_Monsanto_**

Monsanto's acquisitions of other companies over the past three years have totalled £4.8 billion ($8bn). Monsanto Life Science now has three main areas of activity: agriculture, pharmaceuticals – mainly in its Searle division – and production of food ingredients such as NutraSweet. Its agricultural activities are detailed below.

**Key companies acquired include**:

***Plant Breeding International*** (PBIC) - a leading European plant breeder, acquired from Unilever – July 1998
***Cargill's*** foreign seed operations - in South America, Europe, Asia and Africa (excluding UK and Canadian seed companies) – July 1998
***American Home Products*** – reverse take-over/merger with the American pharmaceuticals group – June 1998
***DeKalb Genetics Corp*** - a leading cotton seed breeder - May 1998
***Delta & Pine Land Co*** - a top maize seed producer - May 1998
***Calgene*** - a leading agricultural biotechnology company - 1997
***Agracetus*** – a leading agricultural biotechnology company - 1997
***Holden's Foundation Seeds, Corn States Hybrid Service, & Corn States International*** - maize seed stocks for genetic research and global marketing network - 1997
***Asgrow Agronomics*** – soybean and maize seed specialist, one of the world's top five seed companies - 1997
***Agroceres*** - the largest seed company of the Southern Hemisphere producing hybrid maize, sorghum and vegetables - November 1997
***Seminis*** – grains division. Vegetable seeds division retained by parent company and Mexican conglomerate, Empressa La Moderna – September 1996

**Key strategic agreements include those with**:

***Cargill*** - the world's largest private company, in a worldwide joint venture to create and market new products for the grain processing and animal feed markets - May 1998
***Millenniumm Pharmaceuticals*** - gene mapping specialists - January 1998
***Centro Integral Agropecurario (CIAGRO)*** - to sell GE cotton in Argentina - January 1998
***Stine Seed Company*** - the leading supplier of soybean genetics in early maturing varieties. Non-exclusive research agreement with Monsanto subsidiary, Asgrow – December 1997
***Empresas La Moderna*** - Mexican based company and world's largest vegetable seed producer. Joint investment of $30 million in Mendel Biotechnology in a bid to accelerate their development of GE plants - November 1997
***Maharashtra Hybrid Seed Company*** – to sell GE cotton seed in India - 1997

**Box 2: Multinational control over agriculture and foods**

*'Terminator Technology' will make it impossible to save seed for future planting.*

Whilst maximising the patent owner's profits, seed patenting is highly detrimental to small-scale farmers, particularly in less developed countries where seed saving and sharing are essential for survival. Now, however, if farmers use patented seed, they will be forced to pay royalties if they keep seed to re-sow in following years. This has been a feature of contracts between Monsanto and farmers in the US who grow their GE herbicide resistant 'Roundup Ready' soybean. They have had to agree not to keep seed for future years and to use only Monsanto's brand version of glyphosate (Roundup) on the crop.

As well as global marketing protected under patent monopolies, the ultimate technical mechanism has also been developed to tie farmers into corporate control. A recent US patent application (US 5,723,765) by Delta and Pine Land Co (now owned by Monsanto) and the US Department of Agriculture involves a technique that genetically disables a seed's capacity to germinate again. Dubbed "Terminator Technology" by critics, it will be impossible to save seed for planting the next season. It is being targeted at rice, wheat, sorghum and soybeans with the prospect that seed companies will begin to insist on the use of the technology, gain even greater control over staple food crops and maximise profits through repeated seed sales[12].



**Patents on genes and plants from Third World countries**

Despite their claims that one of the main purposes of developing GE foods is to feed the inhabitants of Third World countries, researchers and companies have claimed patents for plants and genes found in these very same countries – often to their economic detriment. Companies also go gene 'prospecting', with Hoechst collecting plants and soil microorganisms in India and Cameroon, and Monsanto collecting plants and local people's knowledge in the Peruvian Amazon[13].

**Quinoa** originated in the Andes where it is an important local crop. A US patent (5,304,718) was granted to two Colorado State University scientists in 1994 for a naturally occurring male sterile variety, 'Apelawa', and any varieties developed from it. However, a campaign by local people supported by non-governmental organisations in North America has recently led to the patent being withdrawn. Quinoa has recently entered both the US and European markets because of its high protein content which is about twice that of maize and rice. If the patent had remained in force, a developing Andean export market would have been brought under external commercial control[14].

The properties of **the Neem tree** have been recognised in India for centuries where it has been used in a variety of ways, including an extract as an insecticide and twigs as medicated toothbrushes. Many companies have applied for patents based on these well recognised properties. The most recent include Monsanto's patents (US 5,411,736 & US 5,409,708) for neem wax and oil with fungicidal and insecticidal activities. These and other similar patent applications have caused widespread anger in India[15].

**J'oublie** is grown in the Gabon and produces sweet-tasting berries. The sweet compound it contains has been patented by the University of Wisconsin (US 5,527,555; EP 684995). They hope it will succeed in the lucrative sweetener market and have been attempting to engineer bacteria to produce it in the laboratory and remove the need to harvest the plant in Africa. The University is reported to have said that the sweet compound 'brazzein' is its own invention and that the University has no connection with the Gabon[15].

In US patent 5,663, 484, a seed company, Rice Tec, has claimed to have *"invented novel rice lines"* which have the same characteristics as **Basmati rice** and wish to market them as Basmati[16]. Where the genetic material originated from is not clear but may have come from Indian germplasm. Basmati has been grown for centuries in the northern states of India and parts of Pakistan. The Indian Government, which is opposing the patent, fears heavy impacts on their export trade from the use of 'fake' varieties.

## Is Genetic Engineering The Best Solution?

*Many GE crops are unlikely to be available to poor, small-scale farmers.*

The 'life sciences' companies claim that their development of GE crops is essential to feed the world and eradicate starvation. However, added to the issues of market control and cost, GE crops may act against food security for other reasons.

Herbicide resistant crops bring risks to the environment, human health and farming[17] and dependency on external inputs, such as branded herbicides, means that they are unlikely to be available to poor, small-scale farmers. Viruses and pests may develop immunity to the toxins produced by disease and insect resistant crops, thus involving farmers in a costly treadmill of replacing varieties with newer, more potent ones.

Research clearly indicates that new weed problems may be created if advantages such as herbicide and disease resistance are passed to wild native flora, allowing