GM crops – going against the grain

May 2003

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actionaid

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Nearly 800 million people go hungry every day because they cannot grow or buy enough food. One in seven children born in the countries where hunger is most common die before they are five years old.

Many governments, companies and institutions are promoting genetically modified (GM) crops as a response. It is claimed GM technologies will increase food production, reduce environmental degradation, provide more nutritious foods and promote sustainable agriculture. But can GM crops really alleviate world hunger?

ActionAid believes that food security can only be achieved by addressing poverty, matching technologies to local needs, promoting basic rights, protecting biodiversity, and supporting informed choice and participation for poor people. This report – which is based on evidence from Asia, Africa and Latin America – concludes that GM crops are unlikely to contribute to any of these objectives. The expansion of GM is more likely to benefit rich corporations than poor people.

Key statistics

- GM crops covered 58 million hectares worldwide in 2002 – an area two and a half times the size of the UK.
- Only 1% of GM research is aimed at crops used by poor farmers in poor countries.
- It can cost up to $300 million to develop a GM crop and the process can take up to 12 years.
- A small range of GM crops that might address poorer farmers' needs are being researched but they stand only a one in 250 chance of making it into farmers' fields.
- The four corporations that control most of the GM seed market had a combined turnover from agrochemicals and seeds of $21.6 billion in 2001.
- 91% of all GM crops grown worldwide in 2001 were from Monsanto seeds.

Can GM crops help eradicate poverty?

It is not the interests of poor farmers but the profits of the agrochemical industry that have been the driving force behind the emergence of GM agriculture. Four multinational corporations – Monsanto, Syngenta, Bayer CropScience and DuPont – now control most of the GM seed market. Some 91% of all GM crops grown worldwide in 2001 were from Monsanto seeds. By linking their chemicals to seeds via GM technologies, these corporations have been able to extend markets for their herbicides and pesticides.

GM crops are unlikely to help eradicate poverty because yields seem to be no more than non-GM crops and sometimes need more chemicals. Yields from GM soybeans are no higher than those from high-yield conventional varieties. In one study, Monsanto's GM soya had 6% lower yields than non-GM soya and 11% less than high-yielding non-GM soya.

Insecticide use on GM cotton has fallen in some locations, but these gains may be short-lived as insects develop resistance to the insecticide that the cotton expresses. In time, farmers may need to invest in more, not fewer, chemicals. This also applies to chemical use on herbicide-resistant GM crops, which has

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gone up rather than down as farmers use chemicals more frequently and/or in greater amounts. Herbicide use per hectare in Argentina has more than doubled on GM fields compared to conventional varieties.

GM crops are ineffective in tackling the underlying political and economic causes of food insecurity: poverty and inequality. The new GM technologies do not address the essential constraints facing poor farmers including lack of access to land, water, energy, affordable credit, agricultural training, local markets, decent roads, grain stores and infrastructure. In fact, GM could be disastrous for small-scale farmers as the costs are much higher and they risk falling into debt.

Do GM crops meet the needs of poor farmers?

GM varieties do not meet the needs of poor farmers who rely on affordable, readily-available supplies of seeds for a range of crops to meet diverse environmental, consumption and production needs. Poor communities need investment in low-cost, low-input farmer-friendly technologies, building on farmers' knowledge. GM seeds, by contrast, are targeted at large-scale commercial farmers growing cash crops in monocultures. GM crops could undermine food security by wasting the scarce resources of poorer farmers and developing countries.

Most research and development in GM agriculture is conducted by the private sector. Less than 1% of all GM research is directed at poor farmers.

GM research in Africa, for instance, focuses on export crops such as cut flowers, fruit, vegetables, cotton and tobacco, which are grown in large-scale commercial plantations in Kenya, South Africa and Zimbabwe. In Kenya, only one out of 136 intellectual property applications for plants were for a food crop; more than half were for roses.

Do GM crops threaten basic rights?

Farmers in developing countries have evolved complex, cheap and effective systems to save, exchange and use seeds from one harvest to the next. Patented GM seeds threaten to erode these rights and practices, to displace or contaminate seed supplies, and to increase farmers' dependence on private monopolised agricultural resources.

Up to 1.4 billion people, including up to 90% of farmers in Africa, many of them women, depend on saved seed. Yet the proliferation of intellectual property regimes that come with GM seeds threaten centuries-old practices of saving and exchanging seeds.

GM seeds must usually be bought each season. Before they can obtain and use the seeds, farmers have to sign a contract with the company obliging them to pay a royalty or technology fee, to agree not to save or replant seeds from the harvest, to use only company chemicals on them and to give the corporation access to their property to verify compliance.

Having to buy external supplies of seeds and pesticides leaves farmers more economically and agriculturally dependent on corporations. The technology fee makes such seeds prohibitive for the poorest farmers who lack access to credit. The contracts are complex and easily misunderstood by farmers, especially those who are illiterate.

The biotech industry continues to develop a set of GM crop technologies – Genetic Use Restriction Technologies (GURTs), which have been dubbed 'terminator technologies' – that produce sterile seeds: if saved and planted from one year to the next, they would have no yields at all.

Do GM crops threaten biodiversity?

GM crops threaten to reduce the agricultural and crop diversity that are the basis of poor farmer livelihoods and developing country food sovereignty. Three-quarters of the

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original varieties of agricultural crops have been lost from farmers' fields since 1900 as industrial and export-led agriculture has encouraged the widespread monoculture cultivation of a few crop varieties for a more uniform global market. GM crops threaten to erode biodiversity still further.

In addition, GM crops pose known threats to other plants and insects. They can cross-pollinate with non-GM plants, endangering diverse original varieties, particularly in developing countries. They are likely to require bigger and more frequent doses of pesticide as weeds and insects develop resistance to chemicals. They may threaten beneficial insects and thus disrupt natural pest management systems. GM crops engineered to produce pharmaceutical drugs could easily end up in local food supplies.

Biosafety regulations could address some of these problems and threats to biodiversity, but many countries do not have them, or the capacity to develop them. In Zambia, just one person, who has no previous experience of developing national policy or prior knowledge of the issues, is responsible for drafting national biosafety policy.

Nor is regulation enough where national capacity to evaluate and monitor risks is weak. In Brazil, a ban on the commercial cultivation of GM crops did not stop GM soya seeds being smuggled in from Argentina and planted across huge areas. In Pakistan, ActionAid has investigated the impact of illegally-planted GM cotton. Hundreds of farmers who bought the so-called 'miracle' seed on the black market in the hope it would increase their harvests lost around 70% of their crops.

Do GM crops enhance informed choice and participation for poor people?

Developing country governments are under huge pressure to accept GM crops, put scarce public resources into GM research and open their doors to biotech corporations before their people have been properly informed, consulted and agreed to accept, or reject, GM. Poorer farmers and communities are being sidelined in debates and decisions about GM technology.

In South Africa, for example, GM crops have been planted without prior public consultation or involvement in decision-making and without environmental studies on their impact.

Even if GM research takes place in the public sector it may not address the needs of poor farmers because most genes and processes are now patented by corporations. In partnerships between public research organisations and corporations, control and decision-making tends to remain firmly in the hands of corporations who acknowledge that their goal is to create new markets and improve their public image.

If poorer people were more involved in setting agricultural research agendas, they would probably opt not for GM crops, but for other agricultural solutions.

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Conclusion

The widespread adoption of GM crops seems likely to exacerbate the underlying causes of food insecurity, leading to more hungry people, not fewer. To have a lasting impact on poverty, ActionAid believes policy makers must address the real constraints facing poor communities – lack of access to land, credit, resources and markets – instead of focusing on risky technologies that have no track record in addressing hunger.

Recommendations

- Donors and governments should address the wider causes of food insecurity – land, credit, agricultural training and infrastructure – before putting resources into GM crops.
- They should introduce a moratorium on the further commercialisation of GM crops until more research has been carried out into the socio-economic, environmental and biodiversity impacts of GM crops, particularly in developing countries.
- Poorer farmers and communities should be enabled to participate more in national GM debates and policy-making.
- Genetic resources for food and agriculture should be exempt from intellectual property requirements.
- Farmers' rights to save and exchange seeds should be recognised under the intellectual property rules of the World Trade Organisation (WTO) and should be protected in developing country intellectual property rights legislation.
- Governments should introduce competition rules to prevent private sector monopolies and effective institutions to enforce them.
- The potential impact of GM crops on food security, poor farmers and biodiversity should guide the development and implementation of national biosafety frameworks.
- Funding for public sector agricultural research should be increased and should specialise in support for sustainable, farmer-led agriculture.

Introduction

Cultivation of genetically modified (GM) crops has expanded rapidly since they were first grown commercially in the US in 1996. They covered 58 million hectares in 2002, equivalent to two and a half times the land area of the UK.[1] Although cultivation is concentrated in just four countries – the US, Canada, Argentina and China – GM crops are now being grown in and targeted at more countries in the developing world. Proponents claim that GM crops will help feed the world's poor people, reduce environmental degradation and promote sustainable agriculture. We assess these claims against the core principles that guide ActionAid's campaign work on food and trade issues in 13 countries in Asia, Africa and Latin America.

Genetically modified agriculture

The US, Canada, Argentina and China grew 99% of the world's GM crops in 2002. South Africa and Australia accounted for most of the remaining 1%, while a further 12 countries grew under 50,000 hectares *(see Table 1)*. Some 54,000 farmers in India and 2,700 farmers in Indonesia grew GM cotton, while farmers in Colombia and Honduras carried out field tests for the first time in 2002. In total an estimated 5.5 million farmers around the world are now growing GM crops on a commercial scale.[2] Yet the rate at which GM crops are being adopted globally has begun to slow. The 11.5% growth rate between 2001-2002 was significantly less than in previous years, reflecting concern among consumers and farmers about GM.

Over 11,500 field trials for GM crops had taken place in 39 countries by 2000, just under 20% of them in developing countries.[3] Field trials of GM cotton, for example, have taken place in Thailand, India, Indonesia, Bolivia, Colombia, Argentina, Mexico, Kenya, Zambia and South Africa.[4] In Africa, genetic engineering research is taking place in Cameroon, Kenya, Egypt, Ethiopia, Nigeria, Uganda and Zimbabwe on crops as diverse as cowpea, sweet potato, squash, papaya, tomatoes and bananas.[5] Research or field-testing of GM crops is taking place in most countries across Latin America

Table 1 Area and type of GM crops grown in developing countries, 2002

	Area (millions of hectares)	% of developing country total	Type of GM crop
Argentina	13.5	85.0	Herbicide tolerant* (HT) soybean, HT maize
China	2.1	13.0	Bt* cotton
South Africa	0.3	1.9	Bt maize, HT cotton, HT soybean
India	< 0.1	< 1.0	Bt cotton
Uruguay	< 0.1	< 1.0	HT soybean
Mexico	< 0.1	< 1.0	Bt cotton, HT soybean
Indonesia	< 0.1	< 1.0	Bt cotton
Colombia	< 0.1	< 1.0	Bt cotton
Honduras	< 0.1	< 1.0	Bt corn
Total	**15.9**	**100.0**	

From James C, ISAAA 2002

**see page 9*

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and Asia.[6] But most least developed countries do not have the capacity or investment to carry out research into GM crops nor to regulate their import or cultivation.

GM crops are concentrated not just by country but also by crop. The main GM crops now being grown commercially – maize (corn), cotton, canola (oilseed rape) and soya – account for 99% of all GM crops planted in 2002. With the exception of cotton, these crops are used primarily for animal feed. Soya and the vegetable oils derived from canola are used in processed foods.[7]

The global market value for GM seeds in 2002 was estimated to be $4.25 billion, compared to $3.8 billion in 2001 when GM seeds represented 13% of the global commercial seed market.[8]

The pesticide industry was the driving force behind the emergence of GM agriculture. Four multinational corporations – Syngenta, Bayer CropScience, Monsanto and DuPont – now control most of the GM seed market. They had a combined turnover from seeds and agrochemicals of $21.6 billion in 2001.[9] These chemical corporations have bought up seed and biotechnology companies around the world and now have a controlling stake in the world's key agricultural resources. They tried to position GM technology as an essential tool to combat hunger and food insecurity in the developing world. Many developing country governments, tempted by industry claims to boost productivity and address hunger, are keen or are being encouraged to try them.

Biotechnology: a rough guide

Farmers have been involved in plant breeding for as long as they have been engaged in agriculture. Farmers have selectively bred wild plants to create endless new varieties of species best suited to their needs and to local growing conditions.

Plant breeding techniques have become increasingly complex, however, and now involve advanced biological and genetic manipulation. Since the discovery of the structure of DNA, huge leaps have been made in understanding cells, molecules and proteins. Genetic engineering – also known as genetic modification (GM), or recombinant DNA technology – gives rise to genetically modified organisms (GMOs) and involves the transfer of genetic material in the laboratory from one organism to another. Genetic engineering is just one branch of modern biotechnology and can be applied to animals, fish, trees and plants. Other techniques include plant genomics, cloning and proteomics. Modern biotechnology is subject to unprecedented corporate competition, and is leading to the emergence of industrial production systems based on living cells and cell components.

Proponents of GM crops argue that genetic engineering is simply an extension of previous plant breeding techniques. Monsanto states:

> “Today millions of farmers throughout Africa have found great value in using hybrid seeds, and biotechnology seeds simply offer improvements in these hybrids.”[10]

But GM differs in at least two key respects from previous plant breeding techniques. First, it enables genes from one species to be inserted into a completely unrelated species, whereas traditional plant breeding involves only the same or closely related species. Scientists, for example, have created a GM tomato that does not get damaged by frost by inserting into it an anti-freeze gene from the flounder fish. Second, gene technology can produce new varieties more quickly than conventional breeding which is reliant on trial and error.

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Some 99% of GM crops grown commercially have been engineered to exhibit just two characteristics or traits – herbicide tolerance (HT) and insect resistance (Bt) *(see Table 2)*. Herbicide tolerance accounted for 75% of GM crops grown commercially in 2002, the majority of which (62%) was soybean. Insect resistance accounted for 17% of these GM crops, of which GM maize was the most common (13%). Eight per cent of crops now grown commercially have been genetically engineered to exhibit both herbicide and insecticidal traits.[11]

Table 2 GM crops by trait

Crop	Million hectares worldwide	% of total transgenic crops
HT soybean	36.5	62
Bt maize	7.7	13
HT canola	3	5
HT maize	2.5	4
Bt cotton	2.4	4
HT cotton	2.2	4
Bt/HT cotton	2.2	4
Bt/HT maize	2.2	4

Source: James C. 2002[12]

- Herbicide tolerance. Crops – mainly soya, canola, cotton and maize – have been engineered to tolerate certain herbicides.[i] In theory farmers can apply herbicides to their fields to kill weeds and not damage the crop itself. The potential benefits claimed for HT crops are that less herbicide needs to be applied; the herbicides applied are less environmentally damaging; weed control becomes easier and better and thus crop growing needs less labour and gives increased yields; and that soil erosion and water loss is reduced because less tilling of the ground or mechanical weed control are needed.[13]

- Insect resistance. Crops – mainly maize and cotton – have been engineered with a gene from the soil bacterium, *Bacillus thuringiensis* (Bt). This gives the plants themselves insecticidal properties. They express a toxin which kills certain target pests such as the corn borer and cotton bollworm. The potential benefits are that less insecticide needs to be applied; yields are higher because of less pest damage; and fungal damage to the crops is less.[ii]

These crops have been designed for use in temperate climates and stable conditions and may behave differently in tropical and changing conditions. Most rural poor people live in the tropics. An estimated 850 million people live on land threatened by desertification; a further 500 million reside on terrain too steep to cultivate. Because of these and other limitations, two billion people are neglected by modern agricultural science.[14] Will GM agricultural technologies be any different?

GM research

A small amount of research is now being directed at crops that might appear to have a greater potential to address the needs of poor farmers in developing countries *(see Table 3)*. These include:

- crops to withstand extreme environmental conditions such as drought or flooding, or to grow in soils with high levels of acid, salt or heavy metals

- staple food crops such as rice or wheat that grow faster than non-GM versions without the need for extra nutrients, light or water

- crops that are resistant to a host of developing country viruses, pests and bacteria: viral-resistant cassava, rice and sweet potato; nematode-resistant bananas and fungal resistant potatoes are all being researched

- crops with improved post-harvest characteristics such as slower ripening during harvesting or shipping

- crops with an enhanced nutritional content – so-called ‘functional foods’: the most well-known is Golden Rice which is genetically engineered to increase a higher-than-usual vitamin A uptake.

[i] *The two most common types have been genetically engineered to resist either glyphosate and glufosinate ammonium.*
[ii] *Reduced fungal damage (pre- and post-harvest) is the result of fewer insects that can bring diseased organisms into the crop.*

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Table 3 GM crops under research

Crop modification	Description	Aims
Commercialisation		
Insect resistance	• Bt cotton resistant to cotton bollworms, pink bollworms and tobacco budworms	• Reduced insecticide use, better pest control, protected yields
Virus resistance	• Papaya resistant to ringspot virus	• Increased yield
Field studies		
Fungal resistance	• Bananas resistant to black sigatoka	• Crop protection and production, reduced use of fungicide
Virus resistance	• Cassava with increased resistance to African cassava mosaic diseases • Sweet potato resistant to feathery mottle virus	• Crop protection • Crop protection
Bacteria resistance	• Rice resistant to bacterial blight disease	• Benefits to producers
Ripening control	• Banana, pineapple, strawberries, tomatoes	• Extended market life
Factory plants	• Rice producing hepatitis A antibodies for use in vaccines	• Cost savings
Greenhouse studies		
Pest resistance	• Potatoes resistant to nematodes	• Reduced pesticide use
Research laboratory studies		
Abiotic stress	• Tobacco to grow in waterlogged conditions • Crops resistant to aluminium toxicity, such as rice in Mexico • Rice resistant to salt (China) • Crops resistant to drought	• Increased yield • Trials at relatively early stage
Nutrition enhanced	• Rice rich in vitamin A • Plants with increased levels of iron and folic acid • Canola oil rich in vitamin A • Sweet potatoes and rice with enhanced protein • Vegetables that keep their vitamins when cooked	• Improved nutrition content • Possible future development • Improved nutrition, thought to be at least eight years from development
Production enhanced	• Sugar cane with increased sucrose production and improved juice colour	• Better appearance and higher yield
Factory plants	• Banana containing hepatitis vaccine	

Adapted from AEBC. Looking ahead: an AEBC horizon scan. 2002. UK Government [15]

These applications of GM technology appear to offer hope to the world's poor and hungry people. Yet it is doubtful whether any of them will make it into the fields of farmers in the developing world. The science of GM is young and complex and for each gene or trait explored in the discovery stage, the odds are only about 1 in 250 that it will make it to market.[16] The commercial strategy of the biotech corporations is to increase the kinds of Bt and HT crops – GM wheat is next on the horizon – and to extend cultivation of these crops and these traits to developing countries.[17] GM crops for the poor are not a commercial priority. For any of these pipeline crops to reach and benefit poor farmers, substantial improvements in the GM technology and the science behind it are required, along with the implementation of a wide range of public policies governing land reform and security and access to credit and biosafety, to name but a few. None of these seem to be on the immediate horizon.

Introduction

Corporate concentration

The agricultural biotech industry is dominated by a handful of transnational corporations (TNCs). In the 1990s, the chemical pesticide industry bought up biotechnology, plant breeding and seed interests across the developed and developing world. Between 1997-99 pesticide corporations bought $18 billion worth of seed corporations.[18] Monsanto alone bought 60% of the Brazilian maize seed market between 1997-99.[19] After a decade of consolidation, the pesticide industry has a chemical, seed and technology empire that gives them access to farmers and markets around the world – and that gives farmers far less choice about their seed supplier and thus their seeds. By linking their chemicals to seeds via GM technologies, corporations have been able to protect and extend their markets for their herbicides and pesticides, many of the patents on which were due to expire.

Table 4 Leading crop protection and biotechnology companies in 2001

Company	Agrochemical sales ($ million)	Seeds/biotech sales ($ million)	Total
Syngenta	5385	938	6323
Bayer Aventis	6086	192	6278
Monsanto	3505	1707	5212
DuPont	1922	1920	3842
BASF	3114	0	3114
Dow	2627	215	2842
Total	**22,639**	**4,972**	**27,611**

Source: AgriFutura. The newsletter of Phillips McDougall AgriService No 29.[20]

- Six corporations based in the US and Europe controlled 98% of the market for GM crops and 70% of the world's pesticide market in 2000.[21]
- Six corporations own 54% of US plant biotech patents.[22]
- Ten corporations supply 33% of the global seed market compared to thousands of companies 20 years ago.[23]
- 91% of all GM crops grown worldwide in 2001 were from Monsanto seeds.[24]
- In Africa just three corporations – Syngenta, Monsanto and DuPont – now dominate the formal sector seed markets.
- In South Africa Monsanto has complete control of the national market for GM seed, 60% of the hybrid maize market and 90% of the wheat market.[25]

Commercial control of agricultural markets extends beyond agricultural inputs to the whole supply chain, from production through to trade, processing and retailing. The biotech giants have linked up with transnational grain traders and food processors such as Cargill and Archer Daniels Midland. For some crops there is no point of sale from field to fork – one corporation owns or controls the whole food process.[26] This control vastly increases the power of agribusiness corporations to manipulate agricultural prices and markets. It narrows choices for farmers and consumers and leaves them vulnerable to control by TNCs.

GM research is highly protected by intellectual property rights (IPRs). GM crops, genes and GM processes and products are now considered 'inventions' in many countries and thus can be patented *(see Table 5)*. The top six biotech corporations have 2,129 patents in the US, equivalent to 54% of all GM plant patents that have been granted in that country.[27] It can cost from $50 to $300 million to develop a GM crop from the laboratory to the market, a process that can take up to 12 years.[28] Most research and development (R&D) in GM agriculture is conducted by the private, for-profit sector. Six corporations account for almost 65% of the world's total agricultural biotech R&D,[29] spending over $1 billion on GM crop R&D in 1998.[30] But their investment is well protected by the patent system and by quasi-monopoly control over seeds and markets. Gross profits from the GM seed market were $673 million in 2001.[31] As the GM seed market grows, sales of conventional non-GM varieties are declining.[32]

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The commercialisation of agricultural research, protected by patents, has far-reaching implications for the world's poor farmers. GM crops are planted almost exclusively by large commercial growers in rich and middle income countries: less than 1% of all R&D is estimated to be directed at resource-poor farmers.[34]

Table 5 US patents and approved GM crops per trait

Crop trait	Proportion of US patents (%)	Proportion approved crops (%)
Pest resistance	11.4	21.4
Ripening	10.0	8.9
Starch content	10.0	0
Sterility	10.0	8.9
Fungus resistance	8.2	0.0
Fat content/type	8.2	3.6
Bacteria-virus resistance	7.1	8.9
Herbicide resistance	7.1	48.2
Nutrition	6.4	0
Taste	6.1	0
Plant growth	5.0	0
Environmental stress	4.6	0
Flowering	3.2	0
Antibiotic resistance	2.5	0

Source: Harhoff D, Regibeau P & Rockett K. 2001.[33]

ActionAid's Food Rights campaign operates in 13 countries and aims to safeguard poor people's rights and access to safe and nutritious food by addressing food security and key issues in international trade policies.

The campaign is based on five goals and principles, and this report assesses whether GM crops could help to achieve them:

- eradicating poverty
- matching technologies to local needs
- promoting basic rights
- protecting biodiversity
- enhancing informed choice and participation.

Introduction

ActionAid Food Rights campaign work on GM

ActionAid Brazil	is a member of the Brazil GMO Free campaign with six farmers' and consumers' groups, including Greenpeace Brazil. ActionAid Brazil has investigated illegally-planted GM soya in southern Brazil, organised two 'citizens' juries' *(see page 37)* on GM to date and is holding another in Rio de Janeiro in 2003.
ActionAid Pakistan	is making a TV documentary on illegally-grown Bt cotton in Sind province and is lobbying their government on biosafety issues. ActionAid Pakistan mobilised a coalition in 2002 to serve a High Court writ to block the distribution of 6,000 tonnes of GM soybean oil imported from the US as food aid.
ActionAid UK	is a founder of the Five Year Freeze campaign – a coalition of 120 groups calling for a moratorium on the commercialisation of GM. ActionAid UK lobbied the UK government to set up the Intellectual Property Rights Commission – a high-level investigation into the impact of patents on plants and crops.
ActionAid Uganda	has organised MP workshops on GM and works through the national Food Rights Alliance (56 local groups) to raise awareness of GM issues at the grassroots. The Alliance is investigating suspected GM maize trials in west Uganda.
ActionAid Mozambique	has set up a civil society coalition calling for a moratorium on GM and advises that all US GM food aid is milled before being distributed locally.

1 Can GM help feed the poor and eradicate poverty?

Can GM crops help improve livelihoods and food security? Even if GM crops increase agricultural production, for which evidence so far is doubtful, they still fail to address the social and economic inequalities causing food insecurity, and are unlikely to make any positive contribution to alleviating poverty.

The biotech industry claims that GM crops use fewer chemicals and increase yields, and so can help improve the livelihoods of poor people through increased and cheaper food production. Yet there is widespread consensus among farmers that most GM crops have not increased yields. Studies in the US and Canada have found that yields from GM soybeans are no higher than conventional high-yield varieties. In one study, Roundup Ready soya – GM soya engineered to be resistant to Monsanto's herbicide, Roundup – yielded 6% less than non-GM soya and 11% less than high yielding non-GM soya.[35] Other studies have indicated that yields of GM cotton and GM maize did not change in most locations compared to non-GM varieties.[36] There have been reported increases in yields of Bt cotton in the US, Australia,[37] South Africa[38] and India,[39] (though the India study is widely contested). But even where yields have increased, these have not always been enough to offset the higher costs of GM seeds. For example, in a study of Bt corn from 1996 to 2002, farmers in the US lost income overall, even though GM corn yields were better than conventional varieties.[40 41]

Fewer chemicals?

Studies on changes in chemical use between GM and non-GM crops reveal a mixed picture. Insecticide use on Bt cotton has fallen in some locations. However, there is evidence from China and South Africa that these gains may be short-lived as insect resistance to the Bt toxin that the cotton expresses may begin to develop or as outbreaks of secondary pests emerge. [42 43 44] With Bt maize, there have been reductions in chemical use in some locations but increases in others. Even where gains have been achieved, they are lower than those achieved under integrated pest management (IPM) systems, which rely on low-input, sustainable methods to reduce crop damage. The evidence for herbicide resistant crops, meanwhile, is that herbicide use has gone up rather than down – dramatically in some cases – as farmers have to use chemicals more frequently and/or in greater amounts. For example, herbicide use per hectare in Argentina has more than doubled on GM fields compared to conventional varieties.[45] For many resource-poor farmers, reducing chemical use is not a priority, as they cannot afford to farm with chemical inputs in the first place.

Such evidence hardly seems a strong basis from which to recommend GM crops to poor, vulnerable farmers in developing countries. Studies of smallholders growing GM cotton in India and South Africa indicate that yield and pesticide performance is mixed and that where yields are low farmers are vulnerable to debt and further impoverishment.[46] For small-scale farmers in developing countries such problems could mean loss of land and livelihood. Current evidence suggests that poor farmers should exercise caution – on social and economic grounds as well as agronomic and science grounds – before risking their livelihoods by embracing GM crops.

Tackling hunger?

There are currently 799 million people in developing countries who lack the means to

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grow or buy sufficient food for their needs.[47] GM crops are frequently promoted by industry, Western governments and scientists as a means to increase food production and provide food for a growing world population. They promise a greener future of less chemicals and higher yields, giving rise to healthier, cheaper and greater amounts of food. Underlying these claims is an attractively simple, but misleading, view of the world's food crisis that depicts the problem of hunger as being not enough food for too many people and the solution as increasing food production through GM technology.

Yet hunger is not caused by a shortage of food. There is more than enough food in the world to meet current global needs both now and several decades into the future.[49] The underlying causes of food insecurity are political and economic: poverty, inequality, and poor access to land and food. Many people are too poor to buy the food that is available, cannot get access to it because it is badly distributed, or lack the land or other resources to grow food themselves. The biggest constraints for poor farmers is not lack of technology but more essential inputs and necessities: land; resources (such as water and energy); affordable credit; rural

Corporate public relations

The biotech industry works hard to promote its products. The US Council for Biotechnology Information, an industry-funded publicity consortium, has an annual budget of $250 million. Because of substantial criticism, the GM industry has toned down its earlier public relations messages in which it portrayed GM crops as a magic bullet to feed the world. It now uses more sophisticated rhetoric, suggesting that GM is just one of several strategies that can help to feed hungry people. It acknowledges that there is enough food to feed everyone in the world – but then projects current rates of human population growth way into the future to claim that in 10, 20, 30 or 40 years time, there will be an absolute scarcity of food. Overall, the industry's bottom line claim – that GM food is essential if the world's people are not to go hungry – has not changed. DuPont, for instance, states:

> “With more people, we need to provide more resources. Biotechnology alone cannot solve this problem, but it does promise the potential of solutions to global food security and environmental protection.” [48]

Monsanto states “new technologies are required to increase food production to cope with the population increase while at the same time sustain the environment and provide more nutritious foods”. [50] The PR sounds compelling, but GM crops do nothing to address issues of access, distribution, inequity and entitlements. Even if GM crops do result in increased yields that could keep pace with population growth, people would still go hungry as long as the fundamental causes of hunger and food insecurity go unchallenged.

Food insecurity will not be tackled simply by improvements in food distribution and rural infrastructure. Yields and productivity need to rise if food needs are to be met – especially if they are to be met locally. Millions of poor farmers are stuck in a poverty trap in which they cannot afford to invest in their land or develop sustainable production systems. Africa needs special attention – it is the only part of the world where food security has been getting worse in recent decades. Per capita food production on the continent has fallen by about 20% since the mid-1960s.[51] About 70% of Africans live in rural areas and an estimated 50 million families derive their livelihood from farming.[52]

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extension services; access to local markets; decent roads; grain stores and infrastructure.[53]

The concern of the UN's Food and Agriculture Organisation (FAO) and others working in the field is that as long as GM crops are targeted at commercial, large-scale farmers in developing countries, inequality will increase as small-scale farmers become further marginalised in production and trade. Because private sector biotechnology favours the breeding of varieties that are simplified and uniform, and because the little research that it has done on developing country crops has so far focused on high-cash-yielding export crops, the adoption of GM crops has the potential to exacerbate inequalities between large and small farms. For example, GM coffee beans that all ripen at the same time would allow large-scale producers to cut their costs by replacing manual labour with machines, but would force small-scale coffee producers, who tend to have more labour than capital, out of the market.[54] Evidence from Argentina shows that small-scale soybean producers have been edged out of the market, as they are unable to compete with large farms that are better able to capitalise on the time-saving advantages of herbicide tolerant seeds.[55]

Green Revolution

The claim that GM crops will alleviate poverty and hunger assumes that a simple genetic fix can tackle and solve complex problems. But there is good reason to be cautious about a technology-led solution to poverty. Technology is not neutral; it reflects the "dominant social and economic forces at work".[57] The Green Revolution – launched in the 1960s by Western donor agencies to address hunger in poor countries – serves as a warning that a 'one-size-fits-all' technology is unlikely to benefit millions of the world's poor farmers. The Green Revolution introduced a few uniform hybrid crop varieties, which were grown in large monocultures and relied on high chemical inputs and extensive irrigation. It increased yields – mainly of hybrid rice and wheat grown by commercial growers in Asia and Latin America – but gains were eventually offset by resulting soil erosion and the evolution of new diseases and pests, which required ever-increasing amounts of chemicals. In Africa, the Green Revolution failed to deliver the promised benefits as the technologies were unsuited to local conditions, ineffective, expensive and unpopular with poor communities.

What is food security?

Millions of people, including six million children under the age of five, die each year as a result of hunger. One in seven children born in the countries where hunger is most common will die before they are five years old. Most of these deaths are caused not from starvation per se but from a persistent lack of food and essential nutrients.[56]

According to the FAO, food security means that all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for a healthy life.[58] Civil society organisations (CSOs) maintain in addition that the right to adequate food requires food to be culturally acceptable, free from adverse substances and accessible in sustainable ways. CSOs such as Via Campesina, a global peasants' network, call for a broader concept of food sovereignty that encompasses the right of communities, peoples and countries to determine their own agriculture and food policies and to protect and regulate their domestic agriculture in order to meet their food security needs.

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Vitamin A golden rice

Golden Rice is genetically modified with a daffodil gene to produce beta-carotene, a substance that the human body converts to vitamin A. Although Golden Rice is years away from being available to any farmer (and the technology has yet to be transferred into Asian rice varieties), it has been hyped by biotech promoters as a cure for vitamin A deficiency (VAD), a condition that kills one million children annually and is responsible for 14 million cases of eye-damage in pre-school children in developing countries. The rice was developed in the public sector by Swiss and German scientists, but complex licensing arrangements led to a deal with AstraZeneca (now Syngenta). Syngenta offered the technology free of charge to subsistence farmers earning less than $10,000 a year,[59] and promoted the rice as evidence of how GM crops might benefit developing countries.

But Golden Rice may not be the 'silver bullet' solution to VAD. Indeed it could be a big distraction from the problem. People do not have VAD because rice contains too little vitamin A, but because they are poor and their diet has been reduced to little more than rice. A technical solution which puts vitamin A into rice but fails to address poverty and poor diets is unlikely to make any durable contribution to people's well-being.[60] Indeed, a child would need to eat about seven kilograms a day of cooked Golden Rice to obtain the required amount of vitamin A.[61]

The FAO encourages a mixed approach to tackling VAD – health education, supplements to bolster poor diets and local community-based efforts to improve the range of food people eat. Projects in Asia have encouraged people to grow and consume crops rich in vitamin A such as beans, pumpkins, ivy gourd and leafy green vegetables. The Medical Research Council of South Africa supports village-based home-garden programmes in KwaZulu-Natal, promoting the cultivation of carrots, pumpkins and spinach and teaching villagers, especially women, the importance of including them in their diet.[62]

GM crops are promoted as a means to break, or slow down, the chemical treadmill that characterises the Green Revolution because they supposedly need fewer chemical applications. Yet the 'Doubly Green Revolution' threatens to repeat the same mistakes. Its alliance of high-cost science and TNC monopoly control threaten to take agriculture yet further down the road of unsustainable, commercialised agriculture, which encourages monocropping and farmers to become more dependent on privatised, patented resources. Monsanto has genetically engineered a potato that expresses a toxin against the Colorado beetle pest. One critic's observation of this GM potato is pertinent to all GM crops: "Monsanto has constructed the problem as the potato beetle, not as potato monoculture."[63]

1 Can GM help feed the poor and eradicate poverty?

GM crop substitution – devastating rural livelihoods?

There are also some GM crops on the horizon that have the potential to devastate rural livelihoods. GM technology could eventually enable corporations or farmers in rich countries to grow some crops, either in the field or in laboratories, which are currently grown in developing countries. Such crop substitution would deprive export-producing countries of valuable income and employment. Canola, for example, has been genetically engineered to produce oils that could replace coconut and palm oils grown in the developing world.[64] This could devastate coconut oil production in India – where 10 million families rely directly and indirectly on coconut farming for their livelihoods – and oil palm producers in Malaysia and Ghana. Other tropical crops that are vulnerable to GM substitution include vanilla and cocoa. ActionAid discovered in 1999 that Mars UK had two patents on cocoa flavour genes from West African cocoa beans and that DuPont had a patent for a gene that can produce a substitute for cocoa butter.[65]

While crops in the GM pipeline and biotech industry PR might suggest that GM offers hope for millions of farmers struggling to survive from marginal land, GM technologies should be treated with caution. Current evidence finds crop performance is mixed, pesticide use has increased for some crops, and there is a significant potential that the technology could increase inequalities between commercial and small-scale farmers. To have a lasting impact on poverty, agricultural policies must address more essential constraints facing poor farmers: lack of access to land, credit, resources and markets.

2 Does GM technology meet the needs of poor farmers?

Resource-poor farmers rely on affordable, readily available seed supplies that enable them to grow a range of crops that can meet diverse environmental, production and consumption needs. GM seeds, by contrast, are targeted at large-scale commercial farmers growing cash crops in monocultures.

GM proponents point to growth rates for GM crops of more than 10% a year as evidence for their growing importance in food provision globally. But there is cause for concern behind these statistics. Biotech corporations invest in a relatively small number of internationally traded food and fibre crops that have the greatest commercial potential. These are maize, rice, wheat, cotton, soybeans and canola. The US still accounts for 66% of the total GM crop area, while transgenic soybeans account for 62% of all GM crops grown.[66] The proportion of transgenic crops grown in developing countries has increased consistently year on year and now accounts for 27% of global GM acreage.[67] However, the majority of these were grown in Argentina, which is the second largest GM grower in the world and which has a large commercial farming sector. One of the few studies of GM crops in Argentina indicated that the average size farm in a sample of 59 was almost 500 hectares.[68]

The needs of subsistence farmers are almost completely neglected in the product portfolio of the major biotech corporations. Poor farmers cannot afford to pay for these new technologies at levels that would make it attractive for suppliers to enter the market. Crops grown by poor farmers – such as tef, millet, yam, cassava, cowpea and quinoa, indigenous vegetables, roots and tubers – are neglected. As they are not widely produced and are not traded to any significant extent in international markets, they receive little private research investment. Nevertheless, these crops are valued culturally, adapted to harsh environments, nutritious, and are diverse in terms of their genetic and agroclimatic niches.

Emphasis on export crops

Even though poor farmers may not be the most lucrative customers, some developing countries are still of significant interest to the biotech corporations. The TNCs have investments, subsidiaries or joint ventures across Asia, Africa and Latin America. Buying or forming alliances with local companies gives them direct access to markets and supply lines to farmers. However their investment is restricted to crops in those few countries that have a commercial potential. GM R&D in Africa focuses on export sector crops such as cut flowers, fruits, vegetables, cotton and tobacco, the growing of which is dominated by large-scale commercial monocultures in Kenya, South Africa and Zimbabwe.[69] In Kenya, only one out of 136 intellectual property applications for plants filed and tested (GM and non-GM) was for a food crop while more than half were for roses.[70] In the Philippines, the overriding goal of GM research is to improve the competitiveness of crops traded in global markets; hence the emphasis on tried and tested export winners such as mango, pineapple and banana.[71]

2 Does GM technology meet the needs of poor farmers?

Poor farmers and Bt cotton

Transgenic cotton is being grown commercially by smallholder farmers in China, South Africa and India. In each country, the domestic biotech industry has adapted Monsanto's Bt cotton to local varieties.

South Africa is the first country in the world in which small-scale farmers have planted GM crops on a widespread scale. Thousands of small-scale farmers in the Makhathini floodplains in Kwa-Zulu Natal are growing Bt cotton adapted by the South African company Delta Pineland, using a gene owned by Monsanto. This is Monsanto's flagship project, which it uses to promote GM for small-scale farmers and to open up markets in other cotton growing countries such as Uganda. There are about 4,000 small-scale growers in Makhathini, and an estimated 95% had adopted GM cotton by 2001.[72] About 60% have plots of between 10 and 20 hectares. A South African company, Vunisa Cotton, supplies seed, fertiliser, pesticide, credit and information to the farmers and buys their cotton after harvest. Credit is also provided to farmers by the Land Bank of South Africa.

The Bt cotton seeds are twice the price of conventional cotton varieties – the additional GM technology fee accounts for half the price. Yet the number of small-scale farmers growing the GM cotton has increased steadily since 1998. The prospect of Bt cotton seems attractive because the spraying of insecticides is expensive, labour intensive and risks polluting local water sources. In response to a survey about the advantages of Bt cotton, 44% of farmers cited savings on the costs of insecticides, 24% increases in yield and 10% labour savings.[73] One farmer says his yield increased by 27%, he reduced insecticide use by 80% and increased his income by US$150 per hectare.[74] A report for Monsanto concluded that the Makhathini flats "provide a model for smallholder cotton farmers in Africa and across the world".[75]

Yet local CSOs argue that the project's success relies heavily on external assistance, which gives easy access to markets and credit, and it is unlikely to be replicable in market conditions.

Biowatch, a South African campaign group, identified these pitfalls in the project:

- The poorest farmers found it hard to get credit and could not afford to finance the extra seed costs themselves.[76]
- There was widespread misunderstanding about the seed contracts. Many farmers signed them in the belief that they promised seed replacements in the event of crop failures.[77]
- There was poor understanding of the technology itself; farmers thought it meant an end to insecticide spraying and watching out for pests altogether.
- Farmers were not aware of the need to plant 'refuges' (strips of land adjacent to the GM fields planted with non-GM cotton as a strategy to slow the build-up of insect resistance to the Bt toxin) and there have been reported outbreaks of secondary insect damage to crops.[78]

These problems could be addressed over time but groups such as Biowatch and GRAIN, a global biodiversity network, level more fundamental criticism at the whole model. Poor farmers are more vulnerable to price and yield fluctuations and thus could easily fall into debt. According to GRAIN, "Bt cotton may provide a small amount of relief to small farmers in the near term, but it threatens to make matters worse in the end".[79] GM technology does not address the main needs of poor farmers in post-apartheid South Africa, which are land reform, improved access to and control of resources, and the establishment of more equitable and sustainable farming systems.

2 Does GM technology meet the needs of poor farmers?

Biotech corporations are not geared up to deliver pro-poor technologies, even if they did decide to make it their business. Their research and marketing programmes tend to be highly centralised and their resulting products highly uniform and standardised. Small farmers need seeds for conditions that are complex, risky and changeable. Communities in Swaziland, for example, use 200 plant species to deal with a range of

GM sweet potato

One of the few crops of interest to poor farmers that has been genetically engineered is the sweet potato. Monsanto and the Kenya Agricultural Research Institute (KARI), a public body, began a joint project in 1991, with funding from the US Agency for International Development (USAID), to develop a virus-resistant GM sweet potato. Sweet potato is an important crop for rural poor people in Africa: it is grown for food, income and animal feed in a range of agroecological conditions. But yields have declined over time due to pests, and Kenya's average sweet potato yield is now less than half the world's average.[80] In spite of this, the crop has received little attention from public or private agricultural researchers.

The transgenic sweet potato developed by Monsanto and KARI is resistant to sweet potato feathery mottle virus (SPFMV), one of two viruses causing sweet potato viral disease. Laboratory and field trials of the GM crop indicate yield improvements of 18%, with negligible increased costs.[81] The various institutions that have IPRs over the technologies involved are not asking KARI for royalty payments, effectively letting it have the technologies and resulting products for free, and Monsanto has covered an estimated 70% of R&D costs.[iv] As the potato has yet to receive Kenyan regulatory approval, it is too early to say what impact it will have on farmer livelihoods.

While this project appears to be motivated by wishes to help the poor, critics such as the US-based think tank Food First and GRAIN, argue that the GM sweet potato is in fact science-led; that Monsanto had already developed the technology in its home town of St Louis in the US and in Mexico and was simply looking for an application.[82] The project focus on a single virus does not address the main reasons why production of the sweet potato is low in Kenya, which includes a host of agroecological, production and marketing constraints.[83] Moreover, SPFMV is more of a problem for imported exotic varieties of sweet potato than it is for local varieties preferred by the poorest farmers and it is only one of more than 14 known viruses that affect sweet potato. The transgenic sweet potato may not succumb to SPFMV, but the whole project calls into question the use of scarce resources – financial, personnel and equipment – to combat a virus that is not a priority problem for poor Kenyan farmers. The project tied up 19 scientists and involved the support of six institutions, which could have been employed more effectively on supporting alternative, sustainable technologies.[84] According to Food First, the transgenic sweet potato "exemplifies how the excitement over certain genetic engineering procedures can divert research from focusing on the needs of farmers".[85] There are further risks, as with all GM crops, associated with the potential of geneflow and disease resistance *(see page 29)* that could be avoided through low-cost alternatives.[86] The GM sweet potato appears to be little more than a part of a long-term strategy to open up regional markets in Africa to GM crops.[87]

[iv] *The transgenic sweet potato involves a viral coat protein and combines biotechnologies patented by the International Potato Centre, a CGIAR research centre in Peru (see page 39); the Scripps Institute, a private not-for-profit research institute in the US; and Monsanto.*

2 Does GM technology meet the needs of poor farmers?

stresses including poor soil fertility, pests and diseases, and erratic rainfall.[88] Small farms need investment that support and enhance their comparative advantages. Small farms tend to produce yields two to three times higher per hectare than large commercial estates,[89] they generally employ more people per hectare, and the income generated is more likely to be spent on local products that provide employment for landless and land-poor people.[90]

Adapting existing technologies to local conditions requires on-farm trials managed by farmers. The complexities of doing so have been one of the major constraints in traditional crop development and present a major challenge in ensuring that GM seed is appropriate for local needs. Monsanto claims that its technology is “not size specific”, and that GM crops “benefit farmers on any scale – whether farming one, fifty or five hundred acres.”[91] However, even if GM technology addressed local environmental conditions, the constraints and risks facing small farmers such as lack of credit and falling into debt are significantly higher than those facing larger growers.

The private for-profit sector is not responsive to the needs of resource-poor farmers. The GM sweet potato demonstrates that genetic solutions do not address the range of agricultural problems faced by poor farmers. They risk wasting scarce resources that could be better spent on low-cost, farmer-friendly technologies, which could improve food security by building on existing knowledge and low-input farming systems.

3 Do GM crops threaten basic rights?

Farmers in developing countries have evolved complex and effective systems for using, saving and exchanging seeds from one harvest to the next as part of their livelihood strategies. Patented GM seeds threaten to erode these ancient rights and practices and to displace or contaminate seed supplies with GM seeds.

GM crops threaten farmers' rights to save seeds

GM seeds are heavily protected by IPRs, especially patents. These property rights are enforced by restrictive contracts that farmers must sign before they can obtain and use the seeds. The contracts oblige farmers to pay the corporation a royalty or technology fee, to agree not to save or replant seeds from the harvest, to use only proprietary chemicals on them and to give the corporation access to their property to verify compliance.

The length to which corporations are prepared to go to defend their IPRs over GM seeds is demonstrated in the US and Canada. Monsanto has filed at least 475 law suits against farmers and has hired private detectives to identify seed-saving farmers.[92] In one well-known case, Percy Schmeiser, a non-GM farmer in Canada, was accused by Monsanto of growing its Roundup Ready[v] canola without a licence. Schmeiser claimed that he had never planted the seeds and suspects that his canola crop was contaminated by the GM variety by cross-pollination from neighbouring farms. Monsanto sued for the value of his entire crop; Schmeiser was fined $25,000 and ran up costs of $600,000.

In developing countries, the proliferation of IPRs over GM seeds threatens the centuries-old practice of saving and exchanging seeds. Up to 1.4 billion people in developing countries depend on saved seed as their primary seed source and up to 90% of farmers rely on this system in Africa.[93] In many cultures, seed storage and selection are women's responsibilities.

Local knowledge and cultural traditions surrounding seed use are complex and diverse. Farmers constantly select and breed seeds to ensure that they respond to changing growing conditions. Farmers in the Andes cultivate up to 30 varieties of potato in one field to exploit differences in the micro-environment such as soil type or altitude and to maximise different properties such as disease resistance or storage properties.[94] Seed sources are diverse and seed-swapping is common: farmers rely on neighbours, relatives, extension services, local markets and farm supply stores. Resource-poor farmers sometimes experiment with new seed varieties because, although they are rarely suitable for marginal production systems, through cross-breeding they can help enrich the genetic base of their varieties.[95]

GM seeds must be bought each season or farmers must pay royalties if they save them from one harvest to the next. These practices threaten to overturn the basis of many farmers' seed habits: sharing and free access. The implications are far-reaching. Corporate control over GM seeds inhibits farm-to-farm exchange, hitherto the basis of all crop development. It increasingly takes the decisions about which crop varieties to

[v] *Roundup Ready is the proprietary name of Monsanto's GM seeds which are tolerant to its glyphosate, the active ingredient in the company's herbicide Roundup.*

3 Do GM crops threaten basic rights?

develop and grow out of the hands of farmers – very often women – and places them in the hands of industry. Farmers could lose access to locally-adapted varieties as they become displaced or contaminated by GM seeds. This has implications for biodiversity and for farmer choice as GMOs are likely to accumulate quickly in seed stocks and could openly pollinate with local varieties.

Having to buy external supplies of seeds and pesticides leaves farmers economically and agriculturally dependent on corporations and vulnerable to disruptions in supply. Price increases in the technology fee – even if they can be recouped through yield increases and/or cost savings – will be prohibitive for the poorest farmers who lack access to credit. The technology fee inflates the cost of seed considerably; in South Africa GM cotton is twice the price of non-GM cotton seeds; in India Monsanto's GM cotton seeds are three times the price of conventional varieties, even though the corporation does not have a patent in the country.[96] The contracts are complex and easily misunderstood by farmers, especially illiterate ones.

Whether the system of strict farm-level contract enforcement, which has fast taken hold in the US and Canada, will emerge in developing countries depends partly on the GM crops introduced, the intellectual property regimes adopted at a national level, and the degree of corporate influence. The cost of monitoring and enforcing millions of contracts would make such a system difficult to operate in the context of poor smallholder farmers. Yet corporate tactics in the US and Canada show that once a few farmers have been successfully sued, the contracts are enforced more by fear than by the courts.

GURTs

Besides relying on IPRs and legal contracts with farmers, TNCs are also developing additional kinds of GM technologies to retain their control over seeds – Genetic Use Restriction Technologies (GURTs). Two types of GURTs are being developed.

V-GURTs, dubbed 'terminator technology' by critics such as the ETC Group, a Canadian advocacy group, result in genetically engineered crops that produce sterile seeds. If farmers saved and planted seed from one season to the next from a terminator crop, they would probably get no harvest at all in the second year. Supporters claim that this could be a fail-safe way of stopping GMOs from spreading to wild relatives *(see page 29)*. But the technology is widely opposed as exploitative because it forces farmers to buy new seed each season without necessarily adding value to the crop. The FAO has called terminator seeds "generally unethical".[97] Syngenta and Monsanto, which have both patented terminator technologies, promised not to commercialise the seeds after public outcry.

T-GURTs, dubbed 'traitor technology', require chemical triggers to switch on or off traits in the plant. The crop's basic functions – germination, flowering, fruit ripening, sprouting and immune deficiency – depend on external chemicals. This technology promises rich rewards for corporations because they can engineer crops to respond only to their particular brand of agrochemical. Farmers, however, will be faced with greater dependency on corporations, resulting in less choice and less seed security.

3 Do GM crops threaten basic rights?

The expansion of intellectual property rights

Strong rules on IPRs are being globalised via the World Trade Organisation (WTO). The Trade Related Intellectual Property Rights (TRIPs) agreement requires all WTO member countries – currently 146 – to adopt minimum standards of intellectual property protection for plant varieties, either in the form of patents or through what is known as a *sui generis*[vi] system (such as a Plant Variety Protection or PVP system) or a combination of both.[vii] The TRIPs agreement:

- creates minimum standards of intellectual protection that all WTO members must recognise in seven areas
- requires states to make available institutional procedures for rights holders to enforce their IPRs
- provides a procedure for regulating disputes between states concerning their obligations under the agreement.[98]

Patents on life forms such as genes and GM plant varieties are controversial – the US, Japan, EU, Canada and Australia currently grant them – and many believe that genes, plants and agricultural resources more generally should be exempt from IPRs.

Patents and PVP both provide exclusive monopoly rights over an invention or creation for commercial purposes for a set period of time. A patent is a right granted to an inventor to prevent others from making, using or selling the patented invention for 17-20 years without the inventor's permission. The patent holder can also charge others for use of the patented product. The criteria for a patent are that the invention must be novel, inventive and have a commercial use. PVPs give patent-like rights to plant breeders. The criteria are slightly different from those for patents: novelty, distinctness, uniformity and stability.[99] Such criteria favour plant varieties bred by the formal sector as farmers' varieties tend to be genetically heterogeneous, and less stable.

The application of IPRs to agriculture is a recent phenomenon. Living organisms used to be excluded from IPRs because biological material was considered to be part of nature and could not therefore be invented, although it could be discovered. In 1962 the International Union for the Protection of New Varieties of Plants (UPOV) allowed plant breeders to collect royalties on seeds they had bred through conventional plant breeding techniques. Patents on plant varieties were introduced more recently and have quickly become a powerful tool to enhance corporate control over the food chain.

The 1991 version of the UPOV regime restricts the rights of plant breeders to re-use varieties for further breeding and the rights of farmers to sow and re-use seeds.[100] By giving such extensive rights to plant breeders, UPOV not only threatens farmers' rights; it also discounts the contribution farmers have made to developing plant varieties over generations and allows TNCs to monopolise local seed industries.[101]

Many developing countries do not have plant variety protection or patent laws. But TRIPs requires them to introduce such legislation. In Africa, Zimbabwe and South Africa were the only countries with PVP legislation prior to the 1995 introduction of TRIPs.[102] Developing countries are being pressured by the EU, the US and TNCs to adopt the 1991 UPOV system of PVP or to introduce patents on plants. Both these systems are inappropriate for developing countries where farmers rather than corporations constitute the majority of plant breeders. Instead, such countries should be allowed to develop their own *sui generis* systems, as permitted under TRIPs, that best suit their agricultural systems and the needs of their breeders and farmers.[103]

[vi] *'Sui generis' is Latin meaning 'of its own kind'. It means that a country could draw up its own version of an intellectual property system.*

[vii] *WTO member countries can disallow patents on plants and animals, but must provide patent protection for microorganisms. TRIPs does not mention whether or not genes should be patentable, leaving it to national legislation to interpret what constitutes an invention in relation to genetic material.*

3 Do GM crops threaten basic rights?

Sixty patents for GURTs technology were identified by 2000,[104] and more continue to be uncovered in 2003.[105] GURTs effectively transfer power from farmers to corporations. In the absence of strong national and international competition laws, GURTs are likely to increase the monopoly powers of corporations.[viii] The FAO warns that if these GM seeds enter local economies through trade or food aid, fertile and infertile seeds could easily mix.[106] Farmers may find themselves unwittingly sowing sterile seeds or could have no option but to grow infertile seeds or seeds needing chemicals if nothing else was available.

Patents on GM crops violate farmers' traditional rights and practices to save and exchange seeds, and increase farmers' dependence on privatised and monopolised agricultural resources. ActionAid believes that developing countries should exempt plants and food from patents and should implement *sui generis* IPR systems that protect farmers' rights as breeders, cultivators and conservers of genetic seed diversity.

viii GURTs provide further incentive for seed and agrochemical corporations to merge in order to combine their patented technologies and products.

4 Do GM crops threaten biodiversity?

Agricultural and crop diversity are the basis of poor farmer livelihoods and are fundamental to food security. GM crops threaten to damage and reduce this biodiversity and to displace farmers' varieties that have evolved over centuries to meet a range of production, environmental and consumption needs. GM crops pose environmental risks and make the need for developing country government biosafety regulation and monitoring all the more urgent.

Agricultural biodiversity encompasses a wide range of genetic resources: plants and crops; livestock; soil organisms; insects and 'wild' resources. It includes diversity within species, between species and within ecosystems.[107] For thousands of years, farming communities have relied upon and sustained such plant and animal biodiversity as part of their livelihood strategies. They have nurtured and bred food crops and have conserved and improved the genetic resources that form the basis of today's food and agriculture.

Most poor farmers produce a wide range of food, fodder, fuel, medicine and building material from their crops. Their approach tends to be about minimising risk rather than maximising production. Crop diversity is an important survival strategy for poor farmers. They often cultivate large numbers of different plant species in the same field – known as multicropping – that are of considerable genetic diversity, as well as making substantial use of wild plants. These practices help farmers meet their livelihood needs as well as sustain local ecosystems.[108] An important element in the traditional management of crop diversity in developing countries is the use of landraces or farmers' varieties. These are crop varieties that are "conspicuously diverse in their genetic composition"[109] and are selected over time for a range of characteristics including taste, yield, storage, resistance to environmental stress and maturity time. Since farmers first domesticated rice 8,000 years ago, for example, they have developed over 100,000 different varieties.[110] These varieties have been shown to help spread risk more effectively than varieties produced by formal plant breeding institutions.[111]

But crop biodiversity in many places has seriously declined in recent decades. The FAO estimates that three-quarters of the original varieties of agricultural crops have been lost from farmers' fields since 1900.[112] The underlying causes include:

- The rapid expansion of industrial, Green Revolution and export-led agriculture that encourages the cultivatation of relatively few crop varieties in monocultures. This has led to genetic erosion as local varieties are replaced by high yielding varieties (HYVs). In the Philippines, for example, HYVs displaced more than 300 traditional rice varieties that were the principal source of food for generations. In Senegal a traditional cereal known as fonio – which is highly nutritious and robust in difficult growing conditions – is threatened with extinction because it has been replaced by commercial crops.

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- The globalisation of the food system and of marketing, and the extension of patents and IPRs to living organisms have led to the widespread cultivation of fewer varieties for a more uniform, less diverse and more competitive global market.[113]

There is growing evidence of the risks of reduced crop diversity for resource-poor farmers. It can increase their vulnerability to climatic and environmental stresses, raise the risk of crop failure, increase vulnerability to insect pests and diseases, and undermine the stability, sustainability and productivity of established agricultural systems.[114] The high use of chemicals associated with monoculture agriculture has further contributed to a loss of biodiversity in the form of natural pest enemies and beneficial insects as well as target pests. It has led to a decline in soil nutrients and organisms and contributed to the erosion of natural habitats, flora and fauna.

Industry-driven GM technologies continue the trend started by the Green Revolution, taking farmers further down the path of high input, monocrop agriculture in which diverse local varieties that help farmers manage risks are replaced with a few GM varieties.

Environmental impact of GM crops

GM crops also pose several known threats to other plants, insects and the environment more generally. Some of these risks stem from weeds and insects developing resistance to the chemicals applied to or expressed by the GM crops. Others occur when GM crops cross-pollinate with non-GM plants, a phenomenon known as geneflow or genetic contamination. These problems have far-reaching implications in poor agricultural regions if GM crops are commercialised there.

Bt crops

One major concern about Bt crops is that the target insect pests – the cornborer or the cotton bollworm, for instance – will develop resistance to the Bt toxin expressed by the GM plant in the same way that insects develop resistance to chemical pesticides. This leads to a pesticides treadmill in which farmers need to apply more frequent and larger doses of pesticides to kill off insects, until the chemical no longer has any effect on them at all. There are now more than 500 species of insect that are resistant to pesticides.[115] Far from reducing chemical applications, as proponents claim, GM crops threaten to continue and entrench the chemical problems set in train by Green Revolution agriculture.

Although resistance to Bt crops is a major concern, it has not yet emerged as a problem on the ground. But the US Environmental Protection Agency estimates that insects develop resistance to a chemical within three to five years of being constantly sprayed.[116] Insect resistance has serious implications not just for farmers growing Bt crops but also for farmers who spray Bt as a natural insecticide on non-GM crops. For small farmers the loss of this insect control mechanism, could lead to crop failures and economic vulnerability.[117] Integrated pest management techniques – which rely on planting different plants next to each other to manage pest-predator relationships rather than with chemical inputs – are proven to be a far more effective tool to manage pests.[118]

To slow the emergence of Bt resistance in insects, farmers should plant refuges of non-GM crops adjacent to the GM field. Bt cotton farmers in the US are required to plant either 20% of their cotton land with a conventional cotton variety on which they use conventional pest control or to plant about 4% with a conventional variety and use no pest control at all.[119] These refuges are meant to help maintain populations of susceptible non-resistant insects to breed with Bt-resistant insects, with the aim of preventing the resistant insects from becoming dominant. It

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is doubtful whether refuges will be effective in the long run and whether they would help smallholders, especially those with limited land.

Herbicide resistance

Problems of weeds developing resistance to herbicides have been observed with herbicide-tolerant crops as well. In the US there is evidence of weeds becoming resistant to herbicide glyphosate in areas where GM glyphosate-resistant soya is extensively grown.[120] These weeds require heavier applications of herbicides to get rid of them. In 2002, farm advisers in the US reported the appearance of herbicide-resistant horseweed that required 6 to 13 times more herbicide to achieve the same levels of control as normal horseweed.[121] Already more than 400 herbicide-resistant weed types have been identified.[122] In Canada, oilseed rape plants have been found to be resistant to up to three herbidicides after just four years of GM crop planting as a result of gene transfer between different herbicide-tolerant varieties.[123]

GM crops also threaten non-plant biodiversity and non-target organisms. For example, lacewings – which are considered a beneficial insect – are more likely to die when they feed on the larvae of cornborers that have fed on Bt maize.[124] Effects on non-target species could pose problems for pest management in smallholder farming systems that rely on a rich complex of predators and parasites to limit insect damage to crops. In China, Bt cotton is killing the natural parasitic enemies of the cotton bollworm and increasing the numbers of other pests. The study also found that biodiversity in Bt cotton fields in China was lower than in non-Bt cotton fields and that there were more pests.[125]

Geneflow

Geneflow occurs when genes move from a GM crop to wild relatives, non-GM crops or other organisms, a problem that has already been identified in the US and Canada. The likelihood and impact of geneflow depends on local circumstances and the type of crop. Geneflow has been a particular problem with canola. Studies in Canada have shown that pollen from canola can pollinate plants as far as 800 metres away.[ix] [126] The problem of geneflow could theoretically be prevented by ensuring that GM crops are planted at a certain distance away from non-GM crops, but what should this distance be?

There is concern about the evolution of 'superweeds' resulting from gene transfer between GM crops and wild relatives. Wild sunflowers that acquired insect-resistant genes from GM sunflowers became hardier and produced up to 50% more seed.[127] Although superweeds might be less of a direct threat in Africa as few poor farmers use herbicides, there is a risk of geneflow from larger commercial farms to smaller farms. Sorghum, for example, easily hybridises with a weedy relative, Johnson grass, and sugar beet, carrot, ryegrass and white clover all have a high probability of geneflow.[128] [129] The US state of Florida has banned the growing of Bt cotton because of concerns about geneflow to a wild cotton relative.[130]

Protecting centres of genetic origin and diversity

The problem of geneflow poses a direct threat to biodiversity in countries that are centres of genetic origin for particular crops. These are places that have the greatest genetic diversity of a particular crop and where typically the crop has been cultivated for the longest period. Besides the recognised centres of plant genetic diversity *(see Table 6)*, southern Mexico is linked to maize, papaya and upland cotton, and India to oriental cotton, rice and mango.[131]

[ix] *Though just 0.07% of plants were pollinated at this distance, there was a long plateau of 50 to 400 metres in which contamination was 0.2%, close to the limit of 0.25% contamination for elite seed.*

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Table 6 Vavilov centres of plant genetic diversity[x]

Location	Crop type
Ethiopia	barley, coffee, sorghum
Asia Minor	barley, lentils, oats, wheat
Central Asia	apple, chickpeas, lentils
Indo-Burma	eggplant, rice, yam
Indo-Malaya	banana, coconut, sugar cane
China	sorghum, millet, soybean
Central America	bean, corn, tomato
Peru-Ecuador-Bolivia	bean, potato, squash
Southern Chile	potato
Brazil-Paraguay	peanut
West Africa	millet, sorghum
Mediterranean	oats, olives, wheat
North America	sunflower
Northern Europe	oats, rye

Source: Thrupp L. 1997.[132]

Fears of GM contamination within a centre of plant genetic origin were realised in 2002 when DNA from GM maize contaminated non-GM varieties in Mexico.[xi] Mexico is the world's primary centre of maize genetic diversity – it is the region where maize originated and where the greatest diversity is found. These varieties are vital to world food security as they are the raw material used by farmers and breeders around the world to improve the quality and productivity of maize.[133] When a pest destroyed 15% of US maize production in 1970, scientists were able to breed a new (non-GM) pest-resistant variety only after accessing traditional varieties of maize from Mexico.[134] Mexico is also home to the International Maize and Wheat Improvement Centre (CIMMYT), the world's major genebank of maize varieties. So far there is no evidence of GM contamination within the genebank, but the threat is real.

The Mexican government banned GM crops in 1998 to protect this genebank. The source of the contamination is thought to be US GM maize imported for use as flour in tortillas, but planted as seed by farmers. The Mexican government could not discover the origin of the GM seed because Monsanto, Syngenta and Aventis – the three corporations that have commercialised GM maize – refused to disclose the necessary information. Contamination of local seed varieties by GM crops threatens the integrity of local varieties upon which millions of farmers still depend for their livelihoods. The long-term impact of this contamination is unknown but it could narrow choices for today's farmers and future breeders of maize varieties, compromise local food security strategies based on diverse strains and pose a threat to current pest and weed management strategies, a threat for which local farmers are unprepared.

Geneflow – and the associated problems of regulating and containing GMOs – is a challenge for biosafety regulators in developing countries. The practice of saving and exchanging seeds is likely to exacerbate the risk of geneflow as releases of GMOs quickly become established in the local seed supplies.[xii 135] Farmers could soon find themselves unknowingly planting GM crops, leaving them vulnerable to allegations of patent infringement and leaving seed diversity jeopardised.

Biopharming

A further challenge stems from an emerging area of biotechnology that involves modifying plants to produce substances that can be made into industrial compounds or pharmaceutical medicines such as growth hormones, blood clotters, blood thinners, antibodies, HIV vaccines and contraceptives.[136] Most biopharming research has taken place in corn, but soybean, tobacco and rice are also used. Biopharming by corporations such as Monsanto, Dow, Epicypte and Prodigene is still at the R&D stage. There have been 300 field trials in unidentified locations across the US. Biopharming agents acting for biotech firms are seeking new regions to trial crops

[x] *These centres of plant genetic diversity were identified by Russian botanist Nikolai Vavilov in 1949 as major areas of high concentrations of crop diversity. These categories are now widely used in understanding crop origins.*

[xi] *Although the methodology in the study has been queried – the report was originally published in the reputed science journal* Nature *and then retracted by the publishers but not the authors – further research, including a study by the Mexican government, confirmed the presence of GM geneflow.*

[xii] *The persistence of GM strains in the environment will depend on the advantage conferred by natural and artificial selection.*

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and are using the internet to appeal to farmers in developing countries to participate in field trials.[137] One website, www.molecularfarming.com, started its ‘worldwide molecular farming database’ in February 2002, and has potential growers for ‘pharm’ crops in Zimbabwe, India, Pakistan, Nigeria and South Africa, and ‘a contact’ for 147,000 acres in Guinea.[138]

Genetic material from pharma plants could contaminate non-GM crops and end up in the food chain. For example, tobacco has been engineered with a gene by means of a virus vector so that the plant produces a drug, trichosanthin, which is used to induce abortion. The virus is also known to infect tomatoes, peppers and other tobacco relatives.[139] Fears that contamination from these biopharm crops could have serious effects on human health has led to the US food industry opposing biopharming. Biopharmaceutical genes could persist in the environment or accumulate in living organisms, threatening wildlife and non-target organisms.[140] In the US the regulatory approach has been to minimise rather than prevent contamination, and it has paid insufficient regard to environmental and human impacts. In developing countries, where there are currently no regulations or liability for biopharming and where seeds are harder to control because of seed-saving practices, the environmental and human risks are greatly amplified.

Biosafety regulations

Developing countries are making decisions now about whether to grow or import GM crops, and about the kind of system they should establish to govern GMOs. Countries must establish national biosafety frameworks to govern the import of GMOs. They must establish the infrastructure to assess impacts and to evaluate and regulate crop trials and releases of GM plants into the environment and food chain.[141]

At the international level, biosafety issues concerned with the import and export of GMOs[xiii] – are governed by the Cartagena Biosafety Protocol. This was agreed in 2000 as part of the UN Convention on Biological Diversity. Although the Protocol has yet to come into force,[xiv] it provides guidelines for government decision-making on whether or not to accept GMOs into a country. It is based on the principle of Advance Informed Agreement. The Protocol allows governments to take social and economic concerns into consideration when deliberating whether to allow the growing or import of GM seeds, but only if these concerns impact on biodiversity. It incorporates the precautionary principle[xv] – an important feature of many environment agreements – and allows governments to restrict or ban the import of GMOs on the grounds of uncertainty, without the onus of providing scientific proof that a GMO has a particular adverse effect.

The Biosafety Protocol requires each country to implement national biosafety legislation. Countries need to develop the knowledge, skills and capacity to establish, implement and monitor biosafety systems, including risk assessment and regulation. Establishing such provisions involves political and scientific judgements about what constitutes ‘risk’ or ‘adverse effect’ and how much weight is placed on such effects when making decisions. Risk management decisions must be open to revision as new evidence of impacts becomes available. Risk assessment also requires decisions about timeframes – in the US most studies have focused on short-term impacts.

[xiii] *Only GM seeds, and not GM commodities for human or animal consumption, are covered by the Advanced Informed Agreement.*

[xiv] *The Protocol has been ratified by 43 countries so far. It needs 50 countries to come into force.*

[xv] *The most common definition of the precautionary principle derives from the Wingspread statement in 1998: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically."*

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Lack of biosafety regulation is often cited as a constraint to biotechnology taking off in developing countries. Many developing countries, however, have adopted a cautious approach to biosafety, reflecting a broad range of concerns about GMOs. Many governments are unsure about how to position themselves in relation to the market for GM – industry claims about higher yields are enticing but many, especially exporters, are mindful of the tight regulations governing the import of GM foods in Europe and Japan, which could limit their exports.

But most least developed countries do not have regulations in place to import or test GM products.[142] In Zambia, for example, just one person, who has no previous experience of developing national policy or prior knowledge of the issues, is responsible for drafting national biotechnology and biosafety policy.[143]

A regulatory framework is merely the first step, however. Many countries have a regulatory framework but their capacity to evaluate and monitor the risks is weak. In Brazil a ban on GM crops has not been enough to stop GM soya being smuggled across the border from Argentina and planted across huge areas. Bt cotton has been grown without permission in Zimbabwe and without approval in Zambia,[144] and 20,000 hectares of illegal Bt cotton were destroyed in India in 2002. Reports indicate that GM crops are being grown in Malawi and Swaziland without any kind of approval or regulation.[145]

Zambia and food aid

The depth of concern about the potential impact of GMOs was brought into focus in 2002 when Zambia refused 18,000 tonnes of donated GM corn from the US even though 2.5 million people in the country were threatened by hunger. Zambia's rejection provoked a stormy international debate. Although provided for human consumption, farmers often save a portion of food aid as seed for planting. The Zambian government was concerned that GMOs could enter the food chain, pose health and environmental risks and jeopardise its GM-free exports to Europe.[xvi] The US argued that GM crops were safe and refused to label or segregate it. Although non-GM food aid was available at the time one US official accused the Zambian government of 'crimes against humanity'. Zambia, which has yet to formulate national biosafety regulations, defended its right to reject the offer. ActionAid defended Zambia and argued that the US should stop insisting on donating US-grown crops as food aid – a practice known as 'tied-aid' – and instead give money to the UN World Food Programme (WFP) to buy food available in regional markets in Africa.[146] As well as highlighting important issues of national sovereignty, the row confirmed the gulf between the US and Europe on GM crops. Some 35 countries now have current or prospective legislation that impose labelling or import rules on foods with GM ingredients.[147] Europe has refused to license any new GM crops for use in the EU since 1998, pending regulations aimed at ensuring that consumers can avoid GM foods if they wish. In response, the US has turned the issue into a trade war by taking the EU to the WTO dispute panel for infringing WTO rules.

Zambia is not the only country worried about markets for GM produce. The Chinese government tightened the rules on GM imports in 2003 and stopped giving commercial approvals to grow GM crops. Although biosafety concerns were a factor, some claim the decision was prompted by fears of being shut out of export markets.[148]

[xvi] *USAID and WFP were criticised for not obtaining the prior informed consent of countries recieving food aid containing GMO. In the weeks that followed, revelations surfaced that WFP had been delivering GM food and emergency aid for the previous seven years without telling the countries concerned.*

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Weak biosafety legislation and the lack of public information leaves poor farmers vulnerable to sales talk of miracle seeds. Hundreds of poor farmers were enticed to plant Bt cotton illegally in two provinces of Pakistan, according to research by ActionAid Pakistan.[149] About 4,200 acres of Bt cotton was grown in 2002 in four districts of the Hyderabad division of Sindh province and hundreds of acres have been detected in the Punjab. Pakistan has no biosafety regulations in place and many farmers have found that their crop failed miserably. "It's a desperate situation," says Aftab Alam, ActionAid Pakistan Food Rights campaign coordinator. "Hundreds of poor farmers took a gamble with these so-called miracle GM cotton seeds and now 70% have lost their crop. They're in debt and they could lose their livelihoods." ActionAid Pakistan and South Asia Partnerships Pakistan interviewed 38 poor farmers in the Punjab who were initially unaware that the crops were genetically modified and led to believe that the wonder seeds would do well with fewer applications of chemicals.

Since the Biosafety Protocol was agreed there have been modest steps to help poor governments build their capacity and implement biosafety frameworks. The main initiative is a joint Project on the Development of Biosafety Frameworks run by the United Nations Environment Programme and the Global Environment Facility. Funded with $38 million, the project assists 112 countries to prepare biosafety frameworks and improve technical capacity.[150] However, most of the work remains on paper and there has been little progress in actually building technical, scientific and infrastructure capacity. The constraints are substantial – the project has insufficient funds, and human resources in poor countries are in short supply. The biosafety agenda is donor-led and it places pressure on developing countries to implement legislation more quickly than they can manage.

> "I cultivated Bt cotton on half an acre, but right after sowing it was attacked by CLCV [a fungal virus] and the entire field was destroyed. I had to support the marriage of my sister but I could not due to this fallout. The marriage has been put off until next year. I will never again cultivate Bt cotton."
>
> Khalid from Chechanwatni, Sahiwal district, Pakistan.

> "I got a loan to the tune of R150,000 from a local bank and cultivated Bt cotton on five acres of my land. I had another 15 acres cultivation of other crops. Just after two months I had to plough the Bt cotton plot because the crop had become completely destroyed. It cost me R50,000 to cultivate Bt cotton. Not only the amount went in vain but I also lost the income which I could earn had I cultivated the ordinary cotton on that plot. I had to suffer a total loss of R95,000."
>
> Javed Iqbal from Chechanwatni, Sahiwal district, Pakistan.

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The unregulated movement of GM crops – in the form of illegal planting and geneflow from imports, GM food aid and biopharming – violates developing country rights to food sovereignty. Given the known risks to crop biodiversity, the environment and human health posed by GM crops, developing countries need to be given substantial financial and technical aid to build capacity for robust biosafety regulation and monitoring. They also need to be given the freedom to reject GM crops or to impose a moratorium on commercialisation if they wish.

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ActionAid is concerned that developing country governments may rush into accepting GM crops, put scarce public resources into GM research and open their doors to private biotechnology corporations before poor people have been properly informed, consulted and agreed to accept – or reject – GM crops. ActionAid believes that poor farmers should be involved in setting priorities and making decisions on agricultural policy and setting agricultural research agendas.

There is a democratic deficit in decision-making on GM policies, and a lack of active participation and informed choice in many poor countries. The Biosafety Protocol obliges governments to promote and facilitate public education, awareness and participation in decision-making regarding GMOs.[151] There are plenty of participatory tools and approaches that have been used effectively in other policy domains, which are currently under-used in biosafety processes.[152]

Poor farmers and communities – who are well placed to understand the risks and potential benefits of GM crops – are sidelined in debates and decisions about GM technology. In some developing countries, such as South Africa, GM material has been planted without prior public consultation. Given the legitimate public concerns about GM crops, such actions polarise debate and stifle constructive dialogue. The formulation of GM policies should be an open and participatory process in which civil society can contribute and play a determining role.

"The participation of civil society in GM debates is non-existent in Mozambique," says Rogerio Ossemane, advocacy officer for the National Peasants' Union of Mozambique, UNAC. "There is very little knowledge and we just heard that the government was drafting up its policies on GMOs through a national seminar that we attended which ActionAid organised. This is very late to be involved. Introducing GMOs is an irreversible step. You can never go back. We have a large diversity of crops in Mozambique that help to reduce the vulnerability of rural people. We're totally against GMOs and see many dangers with them."

In South Africa, which has allowed five commercial releases of GM crops and has more than 200 field trials underway, there has been minimal civil society involvement in decision-making for approving trials and commercial releases.[153] There have been no environmental studies on the impact of trials or commercial plantings. The development of a national Biotechnology Strategy offered extremely limited opportunities for public interest groups to input, while members of an expert advisory panel included many people with direct or indirect industry interests.[154] The top international corporations in South Africa, along with South African para-statal research institutions, have come together under AfricaBio, an umbrella grouping that is reportedly setting the country's research and biosafety agenda and building its capacity to evaluate GMOs. The person responsible for drafting South Africa's GMO Act left to work with Monsanto's public relations department.[155]

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Indian biosafety lacks accountability

In India public trust in government GM policy has more or less broken down over the last few years, and the commercialisation of Bt cotton has been mired in controversy. After three years of trials, conducted by joint venture Mahyco-Monsanto, the government's Genetic Engineering Approval Committee (GEAC) gave the go-ahead in March 2002 for commercial planting of three Bt cotton varieties. The full results of the trials were not made public. CSOs complained that the government rushed through the approval and the trials were insufficient to test biosafety and agronomic viability. The first commercial growing season ended in December 2002 amid reports of poor performance and infestation by bollworm, the insect that the Bt seeds are engineered to kill. A GEAC team made an assessment at a number of sites after which the Minister of Environment and Forests announced to the Indian parliament that the performance was satisfactory. This contrasts with evidence collected by CSOs who recorded yield losses, quality problems and, in some cases, increased use of insecticides even among the same farmers that the GEAC team visited.[156]

Groups such as the Indian-based Gene Campaign challenged the GEAC. They maintain that the GEAC selected farms used as demonstration plots by Mayhco-Monsanto, conducted the assessment before the season had ended and before the full impact of the Bt cotton was evident, and used a sample of less than 1% of farms. The expert team charged with assessing the performance of the Bt cotton included those who had approved Bt cotton in the first place. The assessment criteria ignored environmental risks, the quality of the cotton, market rates and labour intensity.[157]

CSOs argue that the Indian regulatory system is unaccountable and the government's approach to public consultation is tokenistic.[158] Decisions were taken behind closed doors away from public scrutiny. The Research Foundation for Science, Technology and Education (RFSTE) has taken the Department of Biotechnology to the Supreme Court for improper use of regulations and lack of consultation among the appropriate government departments.

National research decisions must be more transparent and accountable to civil society, especially poor communities. Experience suggests that the challenges to constructive public participation in biosafety legislation set out below are significant:

- Scientific knowledge must be made accessible and useful to non-scientists.
- Controversy over safety and ethical implications has led to polarised debates.
- Commercial confidentiality leads to secrecy which can breed suspicion and distrust of the regulatory system.
- Civil society concerns often extend to social and economic impacts as well as ethical and moral issues. Processes and regulations that seem unresponsive to such concerns are likely to lack public credibility.[159]

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ActionAid has supported citizens' juries in India, Pakistan and Brazil to ensure that the voices of the poorest people are heard in public debate, and that they exercise their right to influence national policy-making on GM crops.[xvii]

ActionAid India organised a farmers' jury in Karnataka, India, in 2000 to facilitate poor people's participation in decisions about whether and under what circumstances to allow commercial planting of GM. The 13-person jury found, by a majority of 9 to 4 (with one invalid ballot), that it would not sow GM seeds. Some felt that such technologies should not be introduced under any conditions, however, other members of the jury put forward recommendations to make GM more acceptable. These included: ensuring no damage to microbes and beneficial insects; pre-commercial trials of 5-10 years to test yield claims and assess safety; environmental and other impact tests in field conditions; involving farmers to ensure the technology is easy to adapt; protecting other crops; restricting GM technologies to non-food crops; retaining farmers' rights to save, breed and exchange seed; and corporate guarantees to protect farmer livelihoods.[160] The jury reached wider conclusions on: the importance of self-reliance for farmers; the value of conserving crop diversity; the need to include farmers as experts in research in agriculture and rural livelihoods; and establishing community seed banks to protect traditional varieties.

The role of the public sector in agricultural research

ActionAid believes poverty is tackled effectively by strategies that enhance choice for poor people and involve them in setting priorities. Yet as seed technologies and other farm inputs are increasingly privatised, ActionAid fears that lack of private sector regulation means agricultural research agendas will become less accountable to poor communities. Many point to the public sector to fill the gaps left by the private sector. But the public sector can be slow to respond to the needs of poor people.

The public sector used to take the lead in crop research in developed as well as in developing countries. Public sector research was underpinned by the free exchange of genetic materials, and breeding technologies were in the public domain. Even when the private sector became involved in plant breeding – for instance, when commercial hybrids offered reasonable economic returns – it still relied on free access to public sector gene banks. None of the Green Revolution hybrid crop varieties were covered by IPRs.

This system reflected the fact that plant breeding is an incremental process that relies on free access to plant material. Today's breeders build on knowledge derived from earlier breeding and today's varieties include knowledge that dates backs generations. Public sector breeding programmes recognised this and, in exchange for free access, provided improved varieties as 'global public goods'.

Recently, however, agricultural budgets in developing countries have come under pressure from structural adjustment programmes and loan conditions requiring public sector cut backs. By 1995, total global spending on agricultural R&D was $33 billion, of which one third was from private sources.[161] Developed countries accounted for 94% of this private spending. Within TNCs, an increasing proportion of agricultural R&D spending is being allocated to GM research – as much as 40% of total agricultural TNC R&D spending in 2000.[162]

[xvii] *Citizens' juries were developed during the 1980s in Germany and the US. Comprising between about 12 and 25 people, the juries are a democratic means of societal input into the policy process. In Karnataka, India, the farmers' jury was guided by a panel of diverse stakeholders and carried out by independent local facilitators.*

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Yet the public sector remains an important source of agricultural research. In 1995, it still accounted for two-thirds of total agricultural R&D spending globally, and as much as 94.5% of research in developing countries.[163] Developing countries have begun to allocate some of their national research budgets to GM technology, though investment remains small, on average between 5–10% of total agricultural budgets. A rough estimate suggests that total investment is $100 to $150 million per year – about half the annual budget of the industry PR group, the US Council for Biotechnology Information.[164] In Kenya, for example, it stands at 2.5%.[165] Foreign aid donors, such as USAID and the Rockefeller Foundation, account for an increasing proportion of R&D funds for GM in poor countries, providing as much as $50 million per year in 2000.[170] In Kenya, 65% of biotech expenditure came from external donors between 1989 and 1996.

Government GM

The biggest developing country investor by far in GM crops is China. It invested $112 million of government money into biotech research in 1999 – a figure projected to increase to $500 million.[166] It claims to have developed 141 GM plants, 65 of which it has approved for release.[167] Brazil, India, South Africa and Mexico also have strong biotech capacities to develop new crops for their own needs.[168] A number of Asian countries, including Japan, Malaysia, Philippines, Indonesia and Thailand, are increasing their commitment to GM crop research. There are also a number of developing countries with a strong tradition of plant breeding that are adapting existing technologies and products from the private sector to local conditions. However, many least developed countries still lack any kind of capacity in genetic engineering. Only three national level research laboratories in sub-Saharan Africa, outside South Africa, are engaged in GM research.[169]

GM advocates justify the use of scarce resources on agricultural biotech research by arguing that the public sector fills the gaps in private sector research by providing GM technologies for poor people. The evidence for this, however, is mixed. The public sector does not always prioritise food security for poor people. An FAO sample of 15 developing countries with a committed interest in biotechnology suggests that public sector research may be more responsive to the needs of poor people than the private sector, but that there is still little research on their priority staple food security crops.

- The top 10 researched crops in the FAO sample countries are: rice (21% of all projects); potatoes (11%); maize (11%), papaya (8%); soybean (7%); sugar cane (5%); cotton (5%); tomato (3%); banana and plantain (3%); and alfalfa (2%). A wide range of other crops together comprise 24% of projects identified.[171]
- Virus and insect resistance are the most commonly-engineered traits, accounting for 31% and 29% of the projects respectively. Improving product quality accounted for 9% of projects. Research targeting fungal resistance, herbicide tolerance, and agronomic properties accounted for 7%, 6% and 6% of the projects respectively. Other traits account for the remaining 12%.

But very little research has progressed beyond field trials and most is still at laboratory stage. Moreover, though developing country-led research could offer some technologies applicable to poor farmer settings, it remains a small percentage of total global research.

One of the reasons that public sector research fails to meet the needs of poor farmers is that research agendas are increasingly being decided in institutional settings rather than in the fields. A review of

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the Consultative Group for International Agricultural Research (CGIAR) *(see below)* found that its genetic engineers made little effort to involve resource poor farmers in needs assessments or priority-setting and that biotechnologists rarely communicated with workers in the field.[172] In contrast to what is needed, the CGIAR says it aims to centralise its operations even further to take advantage of GM technologies.[173] Institutions such as the CGIAR and the Rockefeller Foundation, which now promote GM crop research, are the same ones that tried and failed to bring the Green Revolution to Africa.

One obstacle to improving the responsiveness of public sector GM research to the needs of poor farmers is the proliferation of patents. In adapting existing GM technology, developing countries are heavily reliant on access to existing products, genes or processes, most of which are patented. Access to patented entities can be negotiated through agreements but require legal expertise, experience of managing complex IPRs, human and financial resources. Developing countries report difficulties in managing IPRs and are often at a disadvantage compared to corporations. As more of the basic biotech tools are patented, and as countries become compliant with TRIPs, IPRs will be an increasing barrier to public sector researchers in developing countries that wish to benefit from new research.

Technologies can be subject to multiple ownership across many different countries and institutions, requiring costly and time-consuming negotiations. Golden Rice, for example, is reportedly based on 70 patents originally held by 31 organisations.[174] Brazil's national agricultural research organisation, EMBRAPA, had to negotiate licence agreements with nine corporations before it could release a virus-resistant GM papaya to poor farmers.[175]

CGIAR: meeting the needs of poor farmers?

At an international level, the publicly-funded CGIAR – made up of 16 international research centres – has played a key role in managing seed resources. It has 11 genebanks and 600,000 seed samples that are freely accessible around the world for plant breeders and corporations to adapt and research. These centres manage genebanks of the world's most important food crops to conserve genetic diversity and to maintain genetic material from which improved crop varieties can be developed. This ex-situ conservation is an important complement to in-situ or on-farm conservation in which farmers' skills, as well as the overall ecosystem are critical in maintaining genetic diversity.

CGIAR is beginning to go down the GM path – spending about $25 million of its $340 million budget in 2000 on GM crops.[176] This is welcomed by some as a potential source of pro-poor GM technologies. But although CGIAR's remit is to improve food security and reduce poverty, it often fails to meet the needs of poor farmers.[177] It has been criticised by farmers' groups as a top-down, centralised institution that fails to consult farmers or include them in setting research priorities.[178] CGIAR is at a crossroads and many believe that, in forming alliances with corporations and adopting patenting policies, it is turning away from the needs of poor farmers.

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Public private partnerships – the way forward?

Because of cutbacks in funding, the public sector is often forced to rely on donors, corporate donations or some form of public private partnership (PPP) in order to access resources and knowledge. For example, the publicly funded International Rice Genome Sequencing Project, which decoded the rice genome, did so using raw data placed in the public domain by Monsanto. Corporations promote gene donations as evidence of their commitment to poverty alleviation and food security. Monsanto, for example, states that sharing the rice genome data is part of its "commitment to sharing knowledge and technology with public institutions to advance science and understanding, improve agriculture and the environment, improve subsistence crops, and help smallholder farmers in developing countries."[179] This may be true. Yet these donations are also part of a corporate strategy to create an enabling environment for market acceptance of GM technologies and to deflect criticism from GM opponents. Monsanto's donation of rice genome data, for example, is underwritten with restrictions that prevent public institutions using the information for commercial ends and ensure that the corporation will benefit from any resulting biotech products.[180]

A new corporate initiative, the African Agricultural Technology Foundation, based in Nairobi, Kenya, established by the Rockefeller Foundation and supported by Monsanto, DuPont, Syngenta and Dow AgroSciences, aims to provide free access to a range of patented technologies, including GM, to help tackle Africa's food crisis. The corporations say they are involved for 'noble' reasons, yet acknowledge that they hope to create new markets in Africa and improve their public image.[181]

One problem with the corporate donation model of a PPP is that control remains firmly in corporate hands. Moreover, local resources and priorities can get diverted away from cheaper, more appropriate and sustainable technologies.

PPPs are endorsed as a way forward and their numbers are growing in the area of agricultural research. Examples include:

- research in Kenya and Zimbabwe with the support of the Syngenta Foundation and the International Maize and Wheat Improvement Centre (CIMMYT) to develop Bt maize
- research by the Agricultural Genetic Engineering Institute in Egypt supported by Pioneer Hi-Bred to develop Bt strains and adapt them to maize
- research in Mexico with the support of Monsanto and the Rockefeller Foundation to development virus-resistant GM potatoes for poor farmers.

These partnerships appear to offer advantages to both sides. Developing country scientists gain access to new technologies including: genes and traits; scientific know-how to adapt the technologies; free access to patented technology; training and capacity building. The private sector gets access to: highly-valued knowledge of pathways for local market access; applied breeding skills and infrastructure; understanding of the seed delivery and extension systems; access to local genetic resources.[182] But there is little evidence that such partnerships are meeting the priorities and needs of resource-poor farmers. This is because PPPs are not often targeted at the relevant or most appropriate crops or traits, or because they are not backed up with much-needed social and economic measures to address other poor farmer constraints at the same time. In addition, they can end up diverting much-needed resources away from poor farmers, furthering the trend towards patent-protected research and leaving developing countries more vulnerable to external policy pressures.

5 Do GM crops enhance informed choice and participation for poor people?

- Public sector institutes are increasingly patenting their work in order to facilitate such partnerships. Some CGIAR centres, such as CIMMYT in Mexico and the International Crops Research Institute for the Semi Arid Tropics in India, have re-formulated their policy on IPRs and declared their intention to take out patents on their research for the first time.[183] This signals a significant shift away from public sector benefit sharing and a step closer towards a system in which more of the world's agricultural knowledge and resources are privately controlled. Patent restrictions are likely to choke the free exchange of seeds and technology that nourished the public system in the first place.

- The reliance on industry and donors for GM research can give these players undue influence over the development of national agricultural research policy. It is claimed that following the Kenyan sweet potato research *(see page 21)*, donors and project scientists came to occupy prominent positions in policy-making and advisory circles.[184]

- Private investors can apply pressure on host governments to make changes in national policies. They often complain about a lack of coordination, time-consuming GM approval systems and excessive caution in developing countries.[185] TNCs want stricter IPR protection for their products and biosafety guidelines that speed up approvals and facilitate their rapid commercialisation. There has been pressure, for example, on the Indian government to set up a one-stop approval process for GM crops.[186]

- TNCs have disproportionate power in setting research agendas, which can mean that public research goals become based on commercial rather than food security goals. Interests in promoting a facilitating environment for GM are often undisguised. USAID, for example, aims to "integrate GM food into local systems" and "spread agricultural technology through the regions of Africa".[187]

ActionAid believes PPPs have not, so far, demonstrated their worth in terms of measurable benefits to poor communities. Private sector investment and PPPs need to operate within strong rules and regulations to ensure that control and benefits are more equitably distributed. These need to be accompanied by measures to increase the accountability of public sector research to poor people by increasing their participation in priority-setting and decision-making.

There are many sustainable and affordable alternatives to GM crops for farmers

Does it make sense to invest limited and shrinking public resources in agricultural biotechnology? Poor farmers are usually open to change and innovation, yet returns on high-input, expensive, external technologies have proved limited for marginal areas and poorer people. Farmers want cheap, accessible and managable technologies to help them meet their food needs.

Sustainable agriculture, based on renewable and locally-available inputs and building on farmer knowledge and biodiversity, has helped millions of farmers improve crop performance. In this model, farmers are at the centre of plant breeding, rather than passive recipients of new seeds. Scientists work alongside farmers to strengthen and support their breeding strategies and involve them in genetic conservation, crop improvement, marketing and distribution of seeds. Moreover, genuine sustainable agriculture aims to address the larger socio-economic and political issues that constrain agricultural development and food security.

5 Do GM crops enhance informed choice and participation for poor people?

Successful projects around the world have demonstrated that many available technologies and strategies help farmers meet their food security needs whilst respecting their rights, building on their knowledge and protecting biodiversity.

There is a growing farmers' movement that advocates agroecological approaches based on indigenous farmers' skills and knowledge, and low-input technologies to maintain genetic diversity and increase production. It integrates a range of processes such as nutrient cycling, nitrogen fixing, soil regeneration and the use of natural enemies of pests in food production, and minimises the use of non-renewable inputs. In the largest study of its kind, a database of 208 agroecological initiatives in 52 developing countries – involving 8.9 million farmers – found that improvements in agricultural production and food security were achieved through sustainable and regenerative technologies.[188] For rain-fed crops, production improved by 50% to 100% while farmers cultivating potato, sweet potato and cassava saw yields rise as much as 150%. Importantly, the biggest gains in output occurred in the poorest farming sector. Some examples in the study included:

- 200,000 farmers in Brazil used green manure/cover crops and doubled their maize and wheat yields
- 45,000 farmers in Guatemala and Honduras used the mucuna legume as a cover for soil conservation and tripled their maize yields on hillsides
- 100,000 small-scale organic coffee producers in Mexico increased their production by 50%
- 100,000 small-scale rice farmers in southeast Asia involved in integrated pest management farmers' schools substantially increased their yields and eliminated pesticides
- 200,000 farmers in Kenya used legume-based agroforestry and organic inputs and doubled their maize yields.[189]

Success is enhanced when farmers participate fully in the planning and when appropriate technology is adapted by farmers' experimentation.[190]

Field farmer schools, a form of community-based, non-formal education in which farmers meet in the field to learn about the rice ecosystem are promoted by the FAO. They have been attended by one million farmers in Indonesia, 400,000 in Vietnam and 170,000 in the Philippines. This approach has empowered farmers to become better managers of their crops and has improved production whilst substantially reducing off-farm inputs.[191]

ActionAid supports poor farming communities in all its programmes, from community seed and grain banks to permaculture projects and organic farming. Spectacular production increases have been achieved in a remote region of west Nepal through the grassroots-based Jajarkok Permaculture Programme, an initiative supported by ActionAid Nepal. Hundreds of poor farmers in the hilly regions of Jajarkot and Surkhet were trained in sustainable permaculture principles and transformed areas that used to suffer food shortages into ones that now produce an abundance of honey, fruit, cereals, rice and leafy greens. Yields of wheat and maize have jumped by up to 347% since 1995, and the communities have diversified into cottage industries, including bee keeping, cotton and hemp handlooms, leather processing, candlemaking, agroforestry and kitchen gardening. "Empowering the poor and most marginalised at the grassroots is the best way to achieve local food security," says Yamuna Ghale, ActionAid Nepal's Food Rights campaign coordinator.

Conclusion and recommendations:

The widespread adoption of GM crops seems likely to exacerbate the underlying causes of food insecurity, leading to more hungry people, not fewer. To have a lasting impact on poverty, ActionAid believes policy makers must address the real constraints facing poor communities – lack of access to land, credit, resources and markets – instead of focusing on risky technologies that have no track record in addressing hunger.

Poverty

- Donors and governments should address the wider socio-economic causes of food insecurity – land, credit, rural training and infrastructure – before putting resources into GM crops.

GM crops

- They should introduce a moratorium on the further commercialisation of GM crops until more research has been carried out into the socio-economic, agronomic, environmental and biodiversity impacts of GM crops, particularly in developing countries.
- Poorer farmers and communities should be enabled to participate more in national GM debates and policymaking.

Intellectual property

- Genetic resources for food and agriculture should be exempt from intellectual property requirements.
- Farmers' rights to save and exchange seeds should be recognised under the WTO's intellectual property rules and protected in developing country intellectual property rights legislation.

Corporate concentration

- Governments should introduce competition rules to prevent private sector monopolies and effective institutions to enforce them.

Biosafety

- The potential impact of GM crops on food security, poor farmers and biodiversity should guide the development and implementation of national biosafety frameworks.

Public sector research

- Funding for public sector agricultural research should be increased and should specialise in support for sustainable, farmer-led agriculture.

1 James C. Global status of commercialised transgenic crops: 2002. ISAAA Briefs No 27. 2002.

2 James C. Op cit.

3 Pardey PG & Nienke MB. Slow magic: agricultural R&D a century after Mendel. International Food Policy Research Institute (IFPRI). 2001.

4 Mayer S. Genetically modified cotton: implications for small-scale farmers. Pesticide Action Network UK. 2002.

5 Kuyek D. Genetically modified crops in Africa: implications for small farmers. GRAIN. 2002.

6 FAO. Biotechnology in food and agriculture: conference 8. November 13th to December 11th, 2002. www.fao.org/biotech/C8doc.htm

7 Warwick H & Meziani G. Seeds of doubt: North American farmers' experiences of GM crops. Soil Association. 2002.

8 James C. Op cit.

9 AgriFutura. The newsletter of Phillips McDougall – Agriservice. No 29. March 2002. http://www.avcare.org.au/documents/AgriFutura January2002.pdf

10 http://www.monsantoafrica.com/reports/fieldpromise/page3.html

11 James C. Op cit.

12 ibid.

13 GM crops – trait information. Genewatch 2002. www.genewatch.org/genesrch/traits/traits

14 Altieri M. The case against agricultural biotechnology: why transgenic crops are incompatible with sustained agriculture in the third world? 2002. www.mindfully.org/GE/GE4/case-against-biotech-altieri22aug02.htm

15 Looking ahead: an AEBC horizon scan. 2002. http://www.aebc.gov.uk/aebc/reports/horizon_scanning_report.htm

16 Graff GD & Newcomb J. Agricultural biotechnology at the crossroads. Bio-era Bio Economic Research Associates. 2003.

17 Genetic technologies. A review of developments in 2002. Briefing No 22. GeneWatch UK. 2003.

18 Kuyek D. Op cit.

19 Wilkinson J & Castelli P. The internationalisation of brazil's seed industry: biotechnology, patents and biodiversity. ActionAid Brasil. 2000.

20 AgriFutura. Op cit.

21 Crops and robbers: how patents jeopardise global food security. ActionAid. 2001.

22 Public sector intellectual property resource for agriculture (PSIPRA) database on plant biotech patents cited in Graff GD and Newcomb J. Op cit.

23 Aaron de Grassi & Rosset P. A new green revolution for Africa: myths of agriculture, technology and development. Forthcoming, Food First Books.

24 Ag biotech countdown: vital statistics and GM crops update. ETC Group. June 2002.

25 The seeds of neo-colonialism: genetic engineering and farming. GroundWork and Biowatch South Africa. 2002.

26 Murphy S. Managing the invisible hand: markets, farmers and international trade. Institute for Agriculture and Trade Policy (IATP). 2002.

27 PSIPRA in Graff GD & Newcomb J. Op cit.

28 Graff GD & Newcomb J. Op cit.

29 Ibid.

30 Byerlee D & Fischer K. Accessing modern science: policy and institutional options for agricultural biotechnology in developing countries. AKIS Discussion Paper. World Bank. 2000.

31 Graff, DG & Newcomb J. Op cit.

32 AgriFutura. Op cit.

33 Harhoff D, Regibeau P & Rockett K. Genetically modified food: evaluating the economic risks. 2001. Economic Policy, 33, 263-299 www.economic-policy.org/pdfs/076.pdf

34 Pingali PL & Traxler G. Changing focus of agricultural research: will the poor benefit from biotechnology and privatisation trends? Food Policy, 27. 2002.

35 Warwick H & Meziani G. Op cit.

36 Pretty J. The rapid emergence of genetic modification in world agriculture: contested risks and benefits. Environmental Conservation. Vol 28 (3). 2001.

37 Mayer S.Op cit.

38 Ismael Y, Bennett R & Morse S. Farm-level impact of Bt cotton in South Africa. Biotechnology and Development Monitor. No 48. December 2001.

39 Qaim M & Zilberman D. Yield effects of genetically modified crops in developing countries. Science. 7 February 2003. Vol 299. pp 900-902.

40 Dr Charles Benbrook. The Bt premium price: what does it buy? The impact of extra Bt corn seed costs on farmer earnings and corporate finances. IATP. 2002.

41 Dr Charles Benbrook. When does it pay to plant Bt corn? Farm level impacts of Bt corn 1996-2001. IATP. 2001.

42 Mayer S. Op cit.

43 Xue D. A summary of research on the environmental impacts of Bt cotton in China. Nanjing Institute of Environmental Sciences. 2002.

44 Wynberg R & Pschorn-Strauss E. Bt cotton and small-scale farmers in Makhathini – a story of debt, dependency and dicey economics. GroundWork and Biowatch South Africa. 2002.

45 Qaim M & Traxler G. Roundup Ready soybeans in Argentina: farm level, environmental and welfare effect. Paper presented at 6th ICABR conference on Agricultural biotechnologies. Ravello, Italy. July 2002.

46 Wynberg R & Pschorn-Strauss E. Op cit.

47 Food insecurity: when people must live with hunger and fear starvation. The state of food insecurity in the world. FAO. 2002.

48 www.dupont.com/biotech/difference/global.html

49 Bruinsma J (ed). World agriculture: towards 2015/2030 an FAO perspective. Earthscan Publications London. 2003.

50 www.monsantoafrica.com/monsantoafrica/default.html

51 Pretty, J. Op cit.

52 DeVries J, & Toenniessen G. Securing the harvest: biotechnology, breeding and seed systems for African crops. The Rockefeller Foundation. CABI Publishing. 2001.

53 Kuyek D. Op cit.

54 Madeley J. Robbing coffee's cradle – GM coffee and its threat to poor farmers. ActionAid. 2001.

55 Sue Branford. Why Argentina can't feed itself – how GM soya is destroying livelihoods and the environment in Argentina. The Ecologist. Vol 32 No 8. 2002.

56 Food security: when people must live with hunger and fear starvation. FAO. Op cit.

57 Jefferson RA. Transcending transgenics – are there babies in the bathwater, or is that a dorsal fin? In Pardey P. (ed), The future of food: biotechnology markets and policies in an international setting. IFPRI. 2001.

58 Cited in Tansey G. Food security, biotechnology and intellectual property: unpacking some issues around TRIPs. A discussion paper. Quaker United Nations Office. 2002.

59 Grains of delusion: golden rice seen from the ground. GRAIN. 2001.

60 Aaron de Grassi & Rosset P. Op cit.

61 Vitamin A: natural sources versus 'golden rice'. Greenpeace. February 2001.

62 FAO. Op cit.

63 Koppenburg & Burrows (1996) cited in Pretty J. Op cit.

64 Nair GK. Transgenic rapeseed oil may stifle coconut oil. The Hindu Business Line. 25 January 2003. www.blonnet.com/2003/01/25/stories/2003012500221100.htm

65 Crops and robbers – biopiracy and the patenting of staple food crops. ActionAid. 1999.

66 James C. Op cit.

67 Ibid.

68 Qaim M & Traxler G. Op cit.

69 Kuyek D. Intellectual property rights in African agriculture: implications for small farmers. GRAIN. 2002.

70 Ibid.

71 Newell P. Biotechnology and the politics of regulation. IDS Working Paper 146. Institute of Development Studies (IDS). 2002.

72 Ismael Y, Bennett R & Morse S. Op cit.

73 Ibid.

74 Kuyek D. Genetically modified crops in Africa: implications for small farmers. GRAIN. 2002.

75 Bennett A. The impact of Bt cotton on smallholder production in the Makhathini flats, South Africa. www.monsantoafrica.com/reports/bt_report/BtCotton report

76 Ismael Y, Bennett R & Morse S. Op cit.

77 Wynberg R & Pschorn-Strauss E. Op cit.

78 ibid.

79 Kuyek D. Op cit.

80 Odame H, Kameri-Mbote P & Wafula D. Innovation and policy process: case of transgenic sweet potato in Kenya. Economic and Political Weekly, Vol XXXVII, No 27. July 2002.

81 Ibid.

82 Aaron de Grassi & Rosset P. Op cit.

83 Odame H et al. Op cit.

84 Aaron de Grassi & Rosset P. Op cit.

85 Ibid.

86 Kuyek D. Genetically modified crops in Africa: implications for small farmers. GRAIN. 2002.

87 Aaron de Grassi & Rosset P. Op cit.

88 Kuyek D. Intellectual property rights in African agriculture: implications for small farmers. GRAIN. 2002.

89 FAO. Op cit.

90 Ibid.

91 www.monsantoafrica.com/report/fieldpromise/page3

92 Shand H. Intellectual property enhances corporate monopoly and bioserfdom. Fatal harvest: the tragedy of industrial agriculture. Island Press. 2002.

93 Kuyek D. Intellectual property rights in African agriculture: implications for small farmers. GRAIN. 2002.

94 Creating biodiversity: What is agricultural biodiversity and why is it important? GRAIN. www. http://www.grain.org/themes/dsp_theme.cfm?theme_id=104.

95 Eaton D, van Tongeren F, Louwaars N, Visser B Van Der Meer I. Economic and policy aspects of terminator technology. Biotechnology and Development Monitor 2002 No 49 p19-22.

[96] Bt cotton: caught on the wrong foot. AgBioIndia 19th December 2002. www.agbioindia.org/archive_m.asp?id=150&mo=12&yr=2002

[97] Report of the independent panel of eminent experts on ethics in food and agriculture. First Seminar. FAO. 2001.

[98] Tansey G. Op cit.

[99] Kuyek D. Op cit.

[100] Ibid.

[101] Madeley J. Corporate control of the food chain: the GM link. Consumers International. 2003.

[102] Kuyek D. Op cit.

[103] Integrating intellectual property rights and development policy. Commission on Intellectual Property Rights. UK. 2002.

[104] Syngenta: switching off farmers' rights? ActionAid, Genewatch UK, Berne Declaration and Swedish Society for Nature Conservation. 2000.

[105] Terminator technology – five years later. ETC Group Communique. May 2003.

[106] The potential impacts of genetic use restriction technologies (GURTs) on agricultural biodiversity and agricultural production systems. Commission on Genetic Resources for Food and Agriculture. FAO. 2001.

[107] Thrupp L. Agrobiodiversity loss: conflicts and effects in linking biodiversity and agriculture: challenges and opportunities for sustainable food security. The World Resources Institute. 1997.

[108] Cromwell E, Cooper D & Mulvany P. Agriculture, biodiversity and livelihoods: issues and entry points for development agencies. International Institute for Environment and Development. 2001.

[109] Altieri M. Agroecology: Creating the synergisms for sustainable agriculture. UNDP Guidebook Series. New York 1995. Citing Francis, C.A.(ed.). Multiple Cropping Systems. New York: 1986.

[110] GRAIN. Intellectual property rights: ultimate control of agricultural R&D in Asia. 2001.

[111] Cromwell et al. Op cit.

[112] Crop varieties threatened by pressure on seed banks. International Herald Tribune. 26 August 2002.

[113] Agricultural biodiversity: sustainable use for food security: UKABC www.ukabc.org/ukabc3

[114] Thrupp L. Op cit.

[115] Pretty J. Op Cit.

[116] GroundWork and Biowatch South Africa. Op cit.

[117] Mayer S. Op cit.

[118] Aaron de Grass & Rosset P. Op cit.

[119] Marra MC, Pardey PG & Alston JM. The payoffs to agricultural biotechnology: an assessment of the evidence. IFPRI. 2002.

[120] Warwick H & Meziani C. Op cit.

[121] Ibid.

[122] Pretty J. Op cit.

[123] Gene stacking in herbicide tolerant oilseed rape: lessons from the North American experience. English Nature Research Reports – No 443. English Nature. 2002.

[124] Advisory Committee on Releases to the Environment. Advice for the Secretary of State. 22 July 1998. Significance of new research on effect of toxin on lacewings. Annex A. www.defra.gov.uk/environment/acre/advice/advice02

[125] Xue D. Op cit.

[126] Coghlan A. Keep your distance. New Scientist. Vol 172 Issue 2318 – 24 November 2001.

[127] Genetic technologies. a review of developments in 2002. Genewatch UK. Briefing No 22. February 2003.

[128] Aaron de Grassi & Rosset P. Op cit.

[129] Pretty J. Op cit.

[130] Mayer S. Op cit.

[131] The costs and benefits of GM crops. Developing country background working paper: potential UK impact on developing countries. Strategy Unit. UK Government. 2003.

[132] Thrupp, L. Linking biodiversity and agriculture: agrobiodiversity as a basis for production and survival. World Resources Institute. 1997.

[133] Genetic pollution in Mexico's centre of maize diversity. Food First. Vol 8, No 2. Spring 2000.

[134] The world as a testing ground: risks of genetic engineering in agriculture. HIVOS and Friends of the Earth International. 2002.

[135] Assessing risks and benefits: Bt maize in Kenya. Mwangi PN & Ely A. Biotechnology and Development Monitor. No 48. 2001.

[136] Freese B. Manufacturing drugs and chemicals in crops: biopharming poses new threats to consumers, farmers, food companies and the environment. Genetically Engineered Food Alert. 2002.

[137] Poor farmers warned against internet transgenic crop deals. Nature. Vol 421. 20 February 2003.

[138] Alert: brokering biopharming on the web. The Edmonds Institute. February 2003.

[139] Freese B. Op cit.

[140] Ibid.

[141] Genetically modified crops: the ethical and social issues. Nuffield Council on Bioethics. 1999.

[142] Byerlee D & Fischer K. Op cit.

[143] Lewanika M. Establishing acceptance: biosafety regulations in Zambia. Biotechnology and Development Monitor No. 47. 2001.

[144] Kuyek D. Genetically modified crops in Africa: implications for small farmers. GRAIN. 2002.

[145] Ibid.

[146] US aid and GM food. Greenpeace UK. 2002.

[147] Warwick H & Meziani C. Op cit.

[148] Guterl F. The fear of food. Newsweek. 27 January 2003.

[149] ActionAid Pakistan. Unpublished report. 2003.

[150] Paarlberg, RL. Governing the crop revolution: policy choices for developing countries. IFPRI. 2000.

[151] Public participation and the Cartagena protocol on biosafety. a review for DFID and GEF. The Main Report. IDS. 2003.

[152] Ibid.

[153] GroundWork and Biowatch South Africa. Op cit.

[154] Ibid.

[155] Ibid.

[156] Government lies to the nation on Bt cotton performance. News Release 13th January Greenpeace India. 2003.

[157] Greenpeace Environment Trust memorandum addressed to Indian minister of environment and forests. Re: misrepresentation of farmers' experiences in your statement to parliament on performance of Bt cotton. January 2003.

[158] Public participation and the Cartagena protocol on biosafety. a review for DFID and GEF. Part II: The Case Studies. IDS. 2003.

[159] Ibid.

[160] ActionAid citizens' jury initiative: Indian farmers judge GM crops. Report for ActionAid by Dr Tom Wakeford, Brunel University and National Centre for Biological Sciences, India. ActionAid 2000.

[161] Pardey PG & Nienke MB. Op cit.

[162] Byerlee D & Fischer K. Op cit.

[163] Pardey PG & Nienke MB. Op cit.

[164] Byerlee D & Fischer K. Op cit.

[165] Odame H et al. Op cit.

[166] China: hard to swallow. Business China, Economist Intelligence Unit. 3 February 2003. www.gene.ch/genet/2002/Feb/msg00011.

[167] China leads GM revolution. Nature 25 January 2002.

[168] Byerlee D & Fischer K. Op cit.

[169] DeVries J & Toenniessen G. Op cit.

[170] Byerlee D & Fischer K. Op cit.

[171] Luijben M & Cohen JI. Developing countries forge ahead in crop biotechnology for the poor. Next Harvest: Conference Report. International Service for National Agricultural Research. 2002.

[172] Aaron de Grassi & Rosset P. Op cit.

[173] Ibid.

[174] Byerlee D & Fischer K. Op cit.

[175] Alteiri M. From biotech-mod4@foa.org. November 2002.

[176] Byerlee D & Fischer K. Op cit.

[177] Aaron de Grassi & Rosset P. Op cit.

[178] Unity statement. The people's street conference. Manila. 2002.

[179] International rice genome project completed six years ahead of schedule; Monsanto's data helped accelerate research. Monsanto congratulates international partners for scientific breakthrough in rice. Monsanto news release. 18 December 2002. www.monsanto.com/monsanto/layout/media/02/12-18-02.

[180] GRAIN. Intellectual property rights: ultimate control of agricultural R&D in Asia. 2001.

[181] Gillis J. To feed hungry Africans, firms plant seeds of science. Washington Post. 11 March 2003. Page A01.

[182] Escaler M. Public private partnerships in modern biotechnology. www.scidev.net/dossiers/gmcrops/gmpolicy_escaler

[183] Nottenbury C, Pardey PG & Wright B. Addressing freedom to operate questions for international agricultural R&D in Pardey (ed) Op cit.

[184] Kuyek D. Genetically modified crops in Africa: implications for small farmers. GRAIN. 2002.

[185] Newell P. Op cit.

[186] Scoones, I. Science, policy and regulation: challenges for agricultural biotechnology in developing countries. IDS. 2002.

[187] USAID announces international biotech collaboration says program will help poor countries reduce hunger. 12 June 2002.www.fas.usda.gov/icd/summit/2002/statearchive/USAIDbiotech

[188] Pretty J & Hine R. Reducing food poverty with sustainable agriculture: a summary of new evidence. University of Essex. 2001.

[189] Ibid.

[190] Madeley J. Food for all. the need for a new agriculture. Zed Books. 2002.

[191] Cromwell E et al. Op cit.

ActionAid is a member of the ActionAid Alliance, a network of non-governmental development organisations working together to promote structural changes to eradicate injustice and poverty in the world. ActionAid Alliance members are ActionAid (UK), ActionAid Hellas (Greece), ActionAid Ireland (Ireland), Aide et Action (France), Ayuda en Acción (Spain) and Azione Aiuto (Italy). ActionAid Alliance's members have the regular and active support of more than 600,000 European Union citizens, and its programmes reach over 9 million people in almost 40 countries in Africa, Asia, Latin America and the Caribbean.

ActionAid is a unique partnership of people who are fighting for a better world - a world without poverty.

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