Seeds of doubt

North American farmers' experiences of GM crops

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Preface

Perhaps the greatest achievement of the biotechnology industry has been in creating a myth and then transforming it into a political orthodoxy. It has managed to persuade some of the world's most powerful governments that the 'white heat of biotechnology' can bring benefits of higher yields, lower chemical use, food security and, critically, profitability for farmers.

Those who have signed up seem enthralled by the apparent potential of genetic engineering to improve on nature. Yet, despite growing public alarm (generally dismissed as irrational fears born of scare mongering) the accuracy of these claims have not, until now, been put under the microscope.

In undertaking this study of the actual impact of the commercialisation of GM crops in North America, the Soil Association has gathered sufficient evidence to challenge the fundamental proposition that GM technology represents progress.

The evidence we set out suggests that, in reality, virtually every benefit claimed for GM crops has not occurred. Instead, farmers are reporting lower yields, continuing dependency on herbicides and pesticides, loss of access to markets and, critically, reduced profitability leaving food production even more vulnerable to the interests of the biotechnology companies and in need of subsidies.

The report makes disturbing reading, but at a time when a decision has to be made in the national interest about the commercial introduction of GM crops, we hope it will result in a better informed public debate – and a more independent, less pressurised decision.

Patrick Holden
Director, Soil Association

Executive summary

The UK government and farming community will soon make a fundamental and long-term decision: whether to allow genetically modified (GM) crops to be commercially grown in the UK. The picture the biotechnology industry has painted of GM crops in North America is one of unqualified success, after six years of commercial growing. The objective of this report was to assess whether this image is accurate and if not what problems have occurred. We present interviews with North American farmers about their experiences of GM soya, maize and oilseed rape, and review of some of the independent research.

The evidence we have gathered demonstrates that GM food crops are far from a success story. In complete contrast to the impression given by the biotechnology industry, it is clear that they have not realised most of the claimed benefits and have been a practical and economic disaster. Widespread GM contamination has severely disrupted GM-free production including organic farming, destroyed trade and undermined the competitiveness of North American agriculture overall. GM crops have also increased the reliance of farmers on herbicides and led to many legal problems.

Six years after the first commercial growing of GM crops, the use of genetic engineering in global agriculture is still limited. Only four countries including the US and Canada grow 99 per cent of the GM crops grown worldwide, and just four crops account for 99 per cent of the global area planted to GM crops. In the UK, we have a choice over whether to remain GM-free.

Our findings show that GM crops would obstruct the government from meeting its policy objective that farming should become more competitive and meet consumer requirements. It would also prevent it from honouring its public commitment to ensure that the expansion of organic farming is not undermined by the introduction of GM crops. The Soil Association believes this report will contribute towards a more balanced and realistic debate on the likely impacts of GM crops on farming in the UK and assist an informed decision on the commercialisation of GM crops.

Farming impacts

The direct impacts of GM crops on farmers in North America are examined in chapters 3–6, 8 and 9. Many of the claimed benefits have not been seen in practice and several unforeseen problems have emerged:

- The profitability of growing GM herbicide tolerant soya and insect resistant Bt maize is less than non-GM crops, due to the extra cost of GM seed and because lower market prices are paid for GM crops
- The claims of increased yields have not been realised overall except for a small increase in Bt maize yields. Moreover, the main GM variety (Roundup Ready soya) yields 6–11 per cent less than non-GM varieties
- GM herbicide tolerant crops have made farmers more reliant on herbicides and new weed problems have emerged. Farmers are applying herbicides several times, contrary to the claim that only one application would be needed. Rogue GM oilseed rape plants ('volunteers') have become a widespread problem in Canada
- Farmers have suffered a severe reduction in choice about how they farm as a result of the introduction of GM crops. Some are finding themselves locked into growing GM crops.

Contamination

In chapter 7 we look at GM contamination, which has been the single greatest problem. Widespread GM contamination has occurred rapidly and caused major disruption at all levels of the agricultural industry, for seed resources, crop production, food processing and bulk commodity trading. It has undermined the viability of the whole North American farming industry:

- Contamination has caused the loss of nearly the whole organic oilseed rape sector in the province of Saskatchewan, at a potential cost of millions of dollars. Organic farmers are struggling practically and economically; many have been unable to sell their produce as organic due to contamination

- All non-GM farmers are finding it very hard or impossible to grow GM-free crops. Seeds have become almost completely contaminated with GMOs, good non-GM varieties have become hard to buy, and there is a high risk of crop contamination
- Because of the lack of segregation, the whole food processing and distribution system has become vulnerable to costly and disruptive contamination incidents. In September 2000, just one per cent of unapproved GM maize contaminated almost half the national maize supply and cost the company, Aventis, up to $1 billion.
- One of the most unpleasant outcomes of the introduction of GM crops has been the accusations of farmers infringing company patent rights. A non-GM farmer whose crop was contaminated by GMOs was sued by Monsanto for $400,000
- While biotechnology companies are suing farmers, farmers themselves are turning to the courts for compensation from the companies for lost income and markets as a result of contamination. In Canada, a class action has been launched on behalf of the whole organic sector in Saskatchewan for the loss of the organic rape market.

Economic impacts

The economic impact of GM crops is the focus of chapter 10. GM crops have been an economic disaster. As well as the lower farm profitability, GM crops have been a market failure internationally. Because of the lack of segregation, they have caused the collapse of entire exports to Europe and a loss of trade with Asia:

- Within a few years of the introduction of GM crops, almost the entire $300 million annual US maize exports to the EU and the $300 million annual Canadian rape exports to the EU had disappeared, and the US share of the world soya market had decreased
- US farm subsidies were meant to have fallen over the last few years. Instead they rose dramatically, paralleling the growth in the area of GM crops. The lost export trade as a result of GM crops is thought to have caused a fall in farm prices and hence a need for increased government subsidies, estimated at an extra $3–$5 billion annually
- In total GM crops may have cost the US economy at least $12 billion net from 1999 to 2001.

Legal issues

GM contamination has led to a proliferation of lawsuits and the emergence of complex legal issues (chapter 11):

Farmers' response

The severe market problems have led many North American farmers to seriously question the further development of GM crops (chapters 10 and 11):

- Many US farm organisations have been urging farmers to plant non-GM crops this year
- The US and Canadian National Farmers Unions, American Corn Growers Association, Canadian Wheat Board, organic farming groups and more than 200 other groups are lobbying for a ban or moratorium on the introduction of the next major proposed GM food crop, GM wheat
- With the support of several farming organisations, federal legislation was tabled in Congress in May 2002, to introduce GM labelling and liability rules in the US.


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1 Introduction

The government and UK farming community will soon be taking a decision of fundamental and long-term importance for UK agriculture: whether or not to allow genetically modified (GM) crops to be grown commercially in this country. Currently the UK is among the vast majority of countries in the world where there is no commercial growing of GM crops, and also no market demand. However, this de facto moratorium is set to end with the completion of the government's programme of farm GM trials next spring and following a proposed public debate. Were GM crops to be given the green light and there to be a market, commercial planting could begin as early as autumn 2003.

In September 2001, the Agriculture and Environment Biotechnology Commission (AEBC), the government's independent advisory body on biotechnology and agriculture, published its report, *Crops on Trial*. This said that the GM trials programme alone would not provide enough information for the government to allow commercial growing of GM crops and a decision should only be taken after an independent review of the evidence from those countries where GM crops are already commercially grown. The AEBC also proposed that there should be a broader public debate on GM crops. The Soil Association welcomed this announcement and trusts this report will be a helpful contribution to this debate.

This report reveals the experiences North American farmers have had of growing GM crops and the impacts these crops have had on their industry. Four GM crops have been grown commercially on a large scale for the last six years in the US and Canada. The biotechnology industry has portrayed this experience as successful, suggesting the crops are popular and bring significant benefits to farmers. There has been little questioning of this picture, and it has added to the already substantial pressure for the introduction of GM crops here. In the face of these widely reported industry claims of total success, we set out to see if in fact there were any problems and if so what they were.

To our amazement, the feedback from farmers and industry analysts in North America is that across the whole industry there have been more problems than successes. There have been some beneficial aspects, but a large number of serious problems. Unless these experiences are properly considered, there is a real danger that the forthcoming decision in the UK will be taken on a misleadingly narrow and theoretical basis.

The three year programme of farm-scale GM trials has been repeatedly presented by the government and biotechnology industry as the cornerstone for the decision on GM crops. The AEBC has been critical of this, stressing that there are many important questions that the trials will not answer. The trials have always had a very narrow remit. They are investigating only the short-term impact of the management regime of one group of GM crops, herbicide tolerant GM crops, on farmland biodiversity. They will reveal little about the environmental or wider impacts of GMOs, nor about the impact on farmers and the agricultural industry, and the results will only be applicable to those particular crops and not to commercial growing involving continuous use of one or more GM crops.

Concerns about GMOs have been voiced mainly by the general public and environmental organisations. The major food retailers and manufacturers in the UK have responded by adopting GM-free sourcing policies. In contrast, the apparent interest from the farming industry has probably provided the only real support for the government's wish to proceed down the GM path, apart from the biotechnology sector itself. However, individual farmers who would be the clients of this technology and at the forefront of any negative impacts, have received little information about the implications of GM crops, other than from the biotechnology companies. While there is as yet little data on the potential environmental and health risks, there is now plenty of information on the impact of GM crops on farmers across the Atlantic.

It is important that the UK farming community takes this opportunity to learn the lessons from those who have already tried these crops on a large scale. With UK agriculture still suffering a deep economic crisis, the temptation to seize

a new technology is great. But in North America, farmer ignorance was one of the biotechnology industry's greatest marketing assets – it explains to a large extent how GM crops were introduced there in the first place.

The Soil Association has a particular interest in the impacts of GM crops. The organisation exists to promote sustainable, healthy food production and is the main certifier and promoter of organic food and farming in the UK. To ensure sustainable and healthy food production, the principles of organic agriculture centre on the need for farming practices to be based on natural biological processes and a precautionary approach to safety issues. On this basis, the International Federation of Organic Agriculture Movements (IFOAM), with the full support of the Soil Association, agreed in 1994 that there is no place for GM technology in organic agriculture. Organic production standards worldwide now prohibit the use of GMOs by law. The fact that organic food is GM-free is one of the key reasons for the consumer demand for organic food in the UK.

The organic food sector offers farmers a major and growing high value market. The retail market is now worth about £920 million in the UK and was £15 billion worldwide in 2000,[1] several times larger than the global market for GM seeds estimated at $3.7 billion (the only relevant market is for GM seed; there is no specific demand for GM food).[2] The government is increasingly recognising the economic and environmental opportunities of organic farming and is investing in its development. However, the real danger remains that, should GM crops be commercialised, they could severely damage the sector's future. The Soil Association has expressed concern for many years that GM contamination could disrupt the ability of farmers to supply the organic market and consumers to buy UK organic food. But this problem is not special to the organic sector. As long as the public want a choice of GM-free food and clear labelling of GM products, GM crops have the potential to disrupt the non-organic farming sector as well.

This report will help farmers and farm policy officials to weigh up the merits and drawbacks of GM crops. It looks at the three main GM crops being grown in North America which could also be grown in the UK: soya, maize and oilseed rape. Through a review of some of the academic evidence and farmers' own experiences, it sets out the agronomic, economic and legal impacts on farmers. It examines the immediate impact of GM crops on yield, agrochemical use, and farmer income. It looks at the indirect impacts such as the development of herbicide resistant volunteer plants, contamination, farmer choice and the legal consequences for farmers. It also examines the wider impacts on trade and the farming economy.

2 Context

GM crops around the world

GM crops were first grown commercially in 1996 in the US, but, six years later, most countries are still not growing GM crops. Four countries account for 99 per cent of the total area of GM crops, and they include the US and Canada. The global area stood at 52.6 million hectares in 2001.

The main GM growing countries[1]

Country	*Total area GM in 2001 (million ha)*	*% of global GM crop area in 2001*
USA	35.7	68%
Argentina	11.8	22%
Canada	3.2	6%
China	1.5	3%

The key GM crops and companies

Four main GM crops are being grown commercially: soya, cotton, oilseed rape and maize. They account for 99 per cent of the total global GM acreage.[2] However, only 19 per cent of the global area planted to these crops in 2001 was GM. Three of these GM crops could be grown in the UK: soya, rape and maize; all are used principally for animal feed and vegetable oils and soya is used in a wide range of processed food.

The main GM crops[1]

Crop	*Total area planted 2001 (million ha)*	*% of total area that is GM*
Soya	72	46%
Cotton	34	20%
Oilseed rape	25	11%
Maize	140	7%

These crops have been engineered with just two traits. One set of GM crops are resistant to particular herbicides so that the herbicides can still be applied to the field while the crop plants are growing, for example Roundup Ready (RR) soya, oilseed rape and maize. The other set produce an insecticide, the toxin from the bacteria *Bacillus thuringiensis*, to make the crop, such as Bt maize, resistant to insect attack.

Four companies produce almost all of these four crops. The US company Monsanto dominates the market: in 2000 they accounted for 91 per cent of the total GM area. Syngenta (formerly Novartis/AstraZeneca), Aventis CropScience (formerly AgrEvo, now acquired by Bayer) and Dupont account for virtually all the remaining commercial plantings of GM crops.[2] It is estimated that the global market for GM seeds totalled $3.67 billion last year.[3]

GM crops in the US and Canada

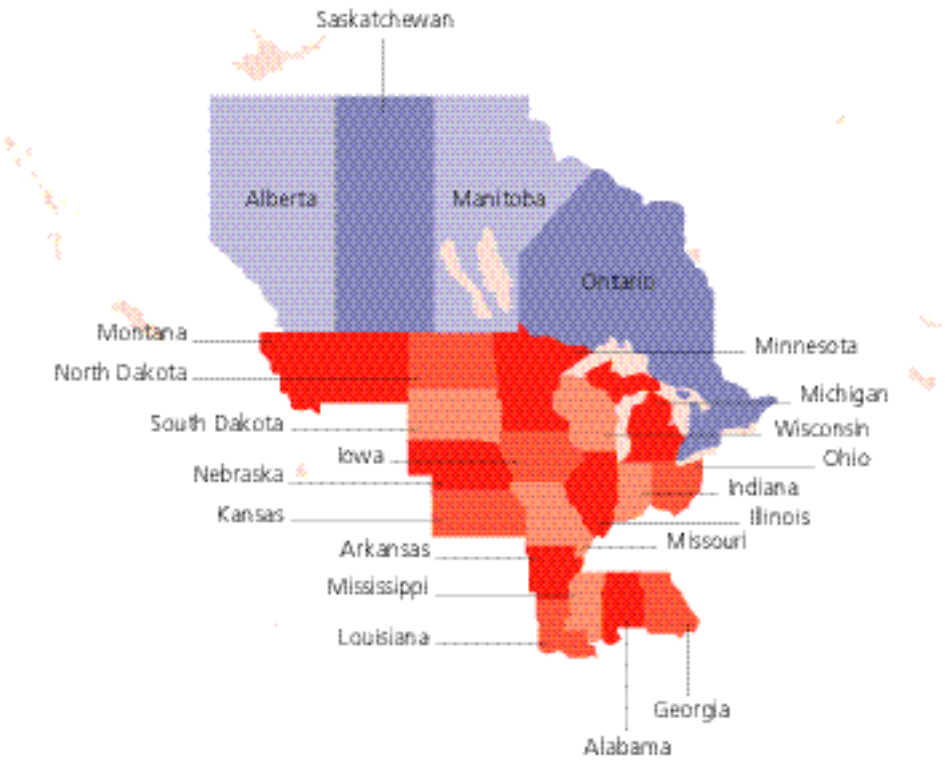
In the US, the principal soya states are: Alabama, Arkansas, North Dakota, South Dakota, Georgia, Illinois, Indiana, Iowa, Louisiana, Minnesota, Mississippi, Missouri, Nebraska and Ohio.[4] Of the three main GM feed crops, the GM soya hectarage grew most rapidly and was about 65 per cent of the total soya area in 2001.

The principal maize growing states are: South Dakota, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio and Wisconsin.[4] According to a survey carried out for the American Corn Growers Association of 509 maize producers, the percentage of the total maize area planted to GM maize in 2001 was 21 per cent (+/-4.5 per cent).[5]

Oilseed rape has only been approved for growing in two US states since 2001. In Canada, oilseed rape is the main GM crop grown on the prairies. Approximately, 60 per cent of the rape there is GM.[6] Maize and soya in Canada are primarily grown in Ontario.[7]

GM policies of UK retailers

All of the major UK food retailers have GM-free policies for their own brand products. The Co-op, Iceland, Marks and Spencer, Safeway, Sainsbury, Tesco and Waitrose have all made statements confirming this position.[8] They are all also in the process of introducing GM-free animal feed policies for their meat and dairy products. For example Sainsbury "is committed to the removal of GM from animal feed," the Co-op is trying to ensure that "no Co-op brand product is derived from animals fed upon a diet containing GM crops" and Safeways informed its



Provinces and states where GM soya, maize and oilseed are grown

suppliers that it wished "to achieve non-GM status for animal feed as soon as possible."[9]

The organic food and farming sector

The global organic food market has being growing rapidly over the last few years and stood at £15 billion in 2000. The US has the largest organic market at almost £5 billion in 2000 and has been reporting annual growth of over 20 per cent The area of organic farmland, however, was only 0.22 per cent of total US farmland. The Canadian organic sector is comparatively underdeveloped, with only 188,000 ha being farmed organically in 2000 and a small organic food market.

The UK has the fastest growing and most import dependent organic market in Europe, with a retail value of about £1 billion in the year to April 2002. The area of organically managed land stood at 3.2 per cent of total UK farmland in 2001, slightly over the EU average of nearly three per cent in 2001. This was farmed by 3,700 producers. The government is investing in the growth of the organic sector and one of its "public service agreements" is an increase in the area of organic farming.[10]

Research for the report

In January and February 2002, one of the authors of this report travelled around the Midwest of the United States interviewing farmers who have been affected by the commercial growing of GM crops. These included farmers who had grown GM crops as well as organic farmers whose livelihoods were threatened by neighbouring GM crops. Literature research was also undertaken – focusing on the data and analysis of independent US and Canadian experts and government bodies, rather than that supplied by the biotechnology industry.

"The application of biotechnology at present is most likely … not to increase maximum yields. More fundamental scientific breakthroughs are necessary if yields are to increase."
USDA, 2001 Agriculture Information Bulletin[1]

3 Yield

GM crops were marketed on the promise of significant yield increases. For example, an advert for Monsanto's Asgrow soya in 2002 stated: "Asgrow varieties return more and yield higher because they're driven by progress,"[2] and in relation to Roundup Ready maize the company claimed "outstanding yields."[3] After six years of commercial production, there is only a limited amount of independent information for farmers on the actual yield performance and other impacts of GM crops. Nevertheless, the information available generally indicates that the outcome has been very different to the claims made by the biotechnology industry.

Analyses of several years of data by a few independent researchers and the Economic Research Service of the United States Department of Agriculture (USDA) show that, for soya, maize, and rape, they have mostly failed to live up to the claims. The results differ between crop and region, and also from year to year. Overall, yields are lower for Roundup Ready (RR) soya and apparently also RR rape, and have increased for only one crop, Bt maize, and then by only a small amount which was not enough to cover the extra production costs. Though there is some information on yield for all GM crops, the most solid evidence available is for RR soya.

RR soya

A poll of 800 Iowa farmers by Iowa State University revealed that the principal reason why farmers chose to plant RR soya (53 per cent) was because they thought it increased yields.[4] However, RR soya stands out as the GM crop that has failed most obviously, with both the research data from US and Canada and farmers' personal accounts testifying to significant yield decreases.

Researchers from the University of Nebraska conducted a controlled field experiment at four locations over two years to evaluate the effect that genetically engineered glyphosate resistance had on soya yield. They compared five Roundup Ready varieties with near isogenic lines – that is crops where the only difference between the GM and non-GM varieties was the genetic modification. They also compared them with high-yielding non-GM soya varieties. In a paper published in *Agronomy Journal* in 2001, they concluded that genetically engineered soya yielded six per cent less than non-GM 'sister lines' and 11 per cent less than high yielding non-GM soya.[5] Importantly, this study is one of the only side by side controlled trials comparing GM crop yields with their identical non-GM varieties; it is also one of the few peer reviewed, published studies on GM yields. It is supported by other research.

In 1999 and 2000, over 10,000 comparative RR versus conventional soya varietal trials were carried out across the US, including a series of independent university trials. Dr Charles Benbrook, an independent agronomy consultant in Idaho, has analysed this data and found that the results are fairly consistent. They show that RR soya produces a yield decline of five per cent to 10 per cent in most circumstances.[6]

Benbrook also took a cross section of the university trial results from three US states and found that comparisons with the top performing conventional varieties provide some even worse results. In Indiana, the top RR variety offered by three seed companies yielded on average 15.5 per cent less than the top conventional variety; in Iowa the reduction was 19 per cent; and in Illinois the reduction was less than one per cent.[6]

This is confirmed by feedback from

Newell Simrall

Monsanto subsidiary Jacob Hartz Seed Company claimed that their Roundup Ready soya seeds were "top quality, disease resistant, high yielding seeds." But the Mississippi state court ruled in September 2001 that they were responsible for the reduced yields obtained by Mississippi farmer Newell Simrall, and confirmed the award of $165,742 in damages to him.[20, 21]

the industry. For example, Canadian soya merchant Gerald Fowler said in 1999 that the reduction is "about 10 per cent quoted by most [farmers] in this area."[7]

These results stand in stark contrast to the claims made by the biotechnology companies. Monsanto literature in 1998 stated that they had achieved an average five percent increase in yields with their RR soya.[8]

Bt maize

In a summary of the studies of various researchers the USDA determined that Bt maize produced higher yields, "in most years and some regions."[9] In a later study Dr Benbrook concluded that Bt maize had resulted in a small yield increase of around 3.9 bushel/acre.[10] The average yield in 2000 was 148 bushel/acre,[11] so this represents an increase of around 2.6 per cent.

HT maize

In 2001, the USDA stated, "adopting herbicide tolerant corn did not increase yields."[1] Again, this contrasts with the impression given by the advertising: "Outstanding yields and reduced input costs… the Roundup Ready corn system costs less, while allowing hybrids to reach their maximum yield potential."[3]

RR rape

A study by University of Saskatchewan researchers published in 1999 revealed that the yields of Roundup Ready oilseed rape fell around 7.5 per cent short of conventional rape. The RR rape managed 33 bushel/acre while the conventional achieved 35.7 bushel/acre.[12]

Backtracking on claims

Many industry supporters have now started to backtrack from the earlier claims about higher yields. In 1999, USDA did a general assessment of the performance of GM crops in 1997 and 1998, including GM cotton, looking at data for the different crops and regions. At the time they concluded that in two thirds of cases, 12 out of 18 crop/region combinations, there were no significant differences in yield between GM and non-

Michael Alberts

Michael Alberts, from Marquette, Nebraska, farms just over 1,000 acres of land, mainly growing maize and soya. He was interested in using Roundup Ready soya as a way of keeping his fields clean but was disappointed to find that "Roundup Ready beans do not yield as well as conventional beans. The conventional beans harvested about 20 bushels/acre more than the Roundup Ready beans."[19]

George Holkup

George Holkup from Wilton, North Dakota was thinking of buying Roundup Ready maize last year, but he was talked out of it by the seed salesman. He was told that it wouldn't canopy and that it was yielding 10–15 bushels/acre less.[22]

GM crops, while in a third of cases GM yield were higher.[13] By 2001, they had concluded that biotechnology was most likely "not to increase maximum yields. More fundamental scientific breakthroughs are necessary if yields are to increase."[1]

Why claims have not been realised

No commercial GM variety has yet been engineered specifically to have a higher physiological yield potential; the focus of genetic engineers so far has been weed and pest management. For this reason, all cases where farmers have experienced increased yields have been as a result of reduced crop damage from pests or reduced weed competition. This also means that yield increases only occur if the control achieved with the GM crop is needed and is greater than would be obtained with conventional methods.[14] In the case of Bt crops, as corn borer attacks are episodic and not always a problem, there is only a yield gain in those regions and seasons where and when pest levels are significant.[15]

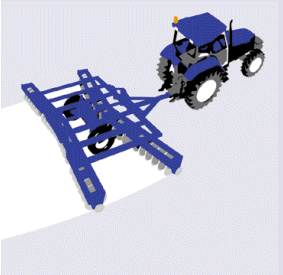
The yield reductions in RR soya seem to result from three specific problems: the use of lower yielding varieties by the breeders, a negative side effect of the genetic engineering process, and a negative side effect of the glyphosate herbicide that is applied to the plants.

The University of Nebraska study concluded that the 11 per cent reduction in RR soya yields was due to two factors. There was a six per cent reduction due to an unintended side effect of the genetic engineering, either related to the gene or to the insertion process. Clearly, this effect had either not been identified prior to commercialisation or had not been publicised. The other five per cent reduction in yield was due to the fact that the GM varieties were based on lower yielding cultivars.[5]

The genetic engineering of RR soya seems to have had a negative side effect on the plant's ability to deal with stress, such as excessive cold or heat, or a mineral or microbial imbalance in the soil. These problems are believed to have arisen because the genetic material that is randomly inserted into RR crops to make them tolerant to the herbicide has also altered the functioning of other biochemical pathways which control the plants' stress responses. The result of this, concluded Dr Benbrook, in a statement in 2002 is

3. **Key points**

- ★ The main reason farmers say they chose GM crops was for increased yields
- ★ On average, the claims of increased yield have not been realised for most GM crops; some have reduced yields
- ★ RR soya yields six per cent less than otherwise identical non-GM varieties and 11 per cent less than high-yielding non-GM soya varieties. This is thought to be partly due to a side effect of the genetic engineering process
- ★ RR rape yields less than non-GM rape
- ★ HT maize has not produced higher yields
- ★ Bt maize produced a yield increase of about 2.6 per cent, which was not enough to offset the higher production costs.



that, "It now appears that RR crops are more vulnerable to certain diseases and insect pests under some relatively common circumstances, which will in the long run either increase the use of other pesticides or decrease yields."[16]

Research published by University of Arkansas scientists in 2000 revealed another unintended side effect: the glyphosate herbicide disrupts the nitrogen fixation process in RR soya. Root development, nodulation and nitrogen fixation were found to be impaired in some RR varieties, and this is exacerbated in dry or low fertility conditions. According to the study, this is caused by sensitivity of the bacteria that fix the nitrogen, *Bradyrhizobium japonicum*, to Roundup.[17] The data revealed that the effect of the delay and decrease in nitrogen fixation means yields can be down by up to 25 per cent.[16] Unfortunately, this information was only available after 100 million acres of RR soya had already been planted in America.

The poor overall yield performance of most GM varieties may be due to a general problem with GM crops. The task that the new gene performs requires additional energy which will detract from the plant's capacity to grow normally.[15]

Where an increase in yields has been reported for a GM variety, it could be due to reasons which are not related to the GM trait. Higher yields may simply be due to the fact that a higher yielding hybrid has been used by the biotechnology companies, rather than necessarily due to the genetic modification; in other words it would have been higher yielding even were it issued as a non-GM variety.[18]

Yield information from farmers will be affected by the availability of different varieties on the market. Farmers in North America have reported that over the last few years, as the GM varieties were introduced, the availability of good non-GM varieties on the market has been significantly reduced.[19] This will to some extent be obscuring the comparative performance of GM and non-GM crops on the ground in favour of GM crops.

There is a final problem with the yields from GM crops. GM varieties increase farmer seed costs by 25 per cent to 40 per cent an acre, so yields have to be higher and/or other costs lower for farmers to break even. Thus, even where the data shows that yields have increased for some farmers, the increase may not be sufficient to avoid the farmers being worse off financially. For example, although US farmers who planted Bt maize harvested on average 3.9 more bushels/acre over the last six years, this still did not cover the extra costs of growing the GM crop. Yield would have had to rise by over another bushel an acre to cover the higher production costs.[10]

"In most regions where Roundup Ready beans have been planted for more than three years, herbicide reliance continues to increase as a result of the combination of weed shifts and resistances."
Dr Charles Benbrook, agronomist, Idaho, 2000[1]

4 Agrochemical use

Bill Christison

Bill Christison is president of the US National Family Farm Coalition. When growing conventional soya, he uses 10 to 12 ounces of chemicals an acre. But he has seen what farmers who are growing Roundup Ready soya are doing. First they spray to clear the ground of weeds before planting, then when the beans emerge, weeds also appear so there needs to be reapplication of Roundup. "Most farmers have found that they should also use a residual herbicide to help kill the weeds because the weeds have become somewhat resistant to Roundup," he explained. "The upshot is that you could easily use 60 to 75 ounces of chemical per acre. What you have is a yield loss and a huge amount more chemical being applied per acre."[2]

Proponents of biotechnology have long claimed that GM herbicide tolerant (HT) and Bt crops would significantly reduce agrochemical use and simplify weed and pest management. They also claimed they would reduce the use of older, more toxic herbicides. These claims were the centrepiece of Monsanto's marketing strategy in 1998 and they have been the main reason put forward by the biotechnology industry for the argument that GM crops could be environmentally beneficial.

However, independent analysis of four years of USDA data indicates that, contrary to the claims, more herbicide and insecticide is being used with HT crops and Bt maize. Some of the benefits have turned out to be short-lived because the intended weed control strategy affected yields and because new weed and volunteer problems have emerged as a result of HT crops. There are indications that the use of GM crops is resulting in a reversion to the use of older, more toxic compounds.

The main reason why GM crops have been popular with farmers has been the attraction of the convenience of herbicide tolerant and insect resistant crops, and the fact that the greater freedom of herbicide use enables more weed control. However, this is being undermined by the emergence of several new weed problems and the need for farmers to take special measures against the development of insect resistance.

4.1 Herbicides

Two herbicide tolerant (HT) GM crops are grown commercially in North America. Roundup Ready crops have been engineered to be resistant to Monsanto's herbicide Roundup, a brand name for the chemical glyphosate. Similarly, though not grown on the same scale, Liberty Link crops are resistant to Aventis' herbicide Liberty, the brand name for glufosinate. The biotechnology companies had claimed that they would require only one application of herbicide.

However, unforeseen problems have meant that herbicide use has not decreased in the way intended. According to independent analyst Dr Benbrook, US government statistics confirm that GM HT crops increased the average amount of herbicide applied to the land.[3]

RR soya

One study of crop data from 172 fields in Iowa concluded that herbicide applications were less frequent on RR soya.[4] However, from USDA data for 1998, Dr Benbrook, concluded that RR soya requires "more herbicides than conventional soybeans, despite claims to the contrary. This conclusion is firmly supported by unbiased field-level comparisons of the total pounds of herbicide active ingredient applied on an average acre of RR soybeans in contrast to conventional soybeans."[5] Comparisons with the extremes of herbicide use were particularly dramatic. Benbrook's analysis revealed that the 10 per cent most heavily treated fields (predominantly RR) required at least 34 times more herbicide than the bottom 10 per cent (planted to non-GM varieties).[5]

By 2001, Benbrook was able to draw on four years of USDA data and concluded that modestly more pounds of herbicides are applied to the average acre of RR soya compared to non-GM soya, and that herbicide use on RR soya is gradually rising.

Glyphosate

Glyphosate herbicides are marketed as benign. They certainly are an improvement over older, more toxic chemicals, but when Monsanto went as far as advertising Roundup as 'biodegradable' and 'environmentally friendly', the New York State attorney general successfully challenged them. Monsanto was required to stop using these descriptions and had to pay $50,000 towards the legal fees.[11]

There is a strong body of independent research that glyphosate, an organophosphorous compound, is harmful. A Californian study showed that it was the third most frequent cause of illness amongst agricultural workers.[12] Harmful effects recorded have included eczema and respiratory problems.[13] It has toxic effects on some beneficial soil organisms, including negative effects on nitrogen-fixing bacteria in legumes, and it increases crop susceptibility to disease. It is very mobile and can leach easily, and can remain active in the soil for over four months. Many of the formulations are acutely toxic to fish.[12]

Glufosinate

Glufosinate is highly soluble and classed as persistent and mobile by the US Environmental Protection Agency. It is toxic to beneficial soil organisms and some aquatic organisms.[14]

In addition, "Average per acre pounds of herbicide applied on RR soybeans exceeds by two to 10-fold herbicide use on the approximate 30 per cent of soybean acres where farmers depend largely on low-dose imidazolinone and sulfonylurea herbicides."[3]

Indeed, as early as 1997 it was evident that the claims that RR soya would require no more than one application were foundering. An Iowa State University scientist revealed to a British crop protection conference that, while in 1996 a single application of herbicide had been used for RR soya, in 1997, planting conditions were different and unless alternative weed management was included, a second, or even third application was necessary.[6]

This contrasts with Monsanto's claims that "herbicide use was, on average, lower in Roundup Ready soyabean fields than in other US soyabean fields" and that a reduction of 22 per cent was to be expected.[7]

RR maize

According to Dr Benbrook, USDA data also revealed that, in 2000, RR maize was treated with about 30 per cent more herbicide on average than non-GM maize.[3]

Liberty Link maize

Maize growers have found that Liberty Link does not achieve adequate weed control without repeated applications of glufosinate. A majority are therefore now using the more toxic, persistent herbicide atrazine in addition to glufosinate, according to Dr Mike Owen of Iowa State University. Aventis/Bayer had claimed that one of the main benefits of the GM maize would be the substitution of atrazine with glufosinate.[8]

HT rape

A survey of crop management practices of 650 oilseed rape growers in Canada of the 1997 to 2000 crop, carried out by the Canadian canola industry, found HT rape had been treated on average about 20 per cent more often than non-GM crops, with 2.1 herbicide applications to Roundup Ready and Liberty Link crops compared to 1.8 applications to non-GM crops.[9] Though farmers may reduce their use in the first year, they are using more in the following years to control volunteer GM rape.[10]

Why herbicide use has not gone down

Increases in herbicide use were probably to be expected with HT crops. Both glyphosate and glufosinate are broad spectrum herbicides that are toxic to most plants including normal crop plants, so they normally cannot be applied to a field once the crop has grown. GM herbicide tolerant technology means that farmers can now use these chemicals during the growing period. Farmers are generally keen to eliminate as many weeds as possible and often aim for completely 'clean' fields, even if complete weed control is not necessary or advisable in overall economic terms. HT crops enable farmers to achieve this aim. For example, easier and better weed control was the top reason given by western Canadian growers for chosing HT rape.[9] While HT crops are therefore a very easy and attractive option for farmers, they set agriculture back on a more chemical dependent path.

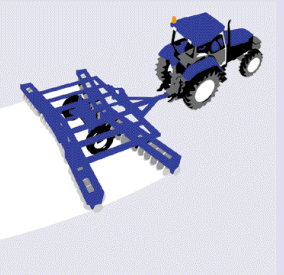
The claim that GM crops would result in lower agrochemical use was based on the flexibility of being able to use the herbicide at any time. This meant that it could then be applied at the most effective time for weed control, and thus require only one application. However, farmers have found that, for a single application to be sufficient for weed control purposes, it needs to be applied at a late stage in crop development, by which time the weeds have been present most of the time and caused a yield loss. In practice, most farmers are therefore applying herbicides several times throughout the life cycle of the HT crop.[6] This could be anything up to six applications of glyphosate in total.[15] Many farmers are also still using other herbicides as well as glyphosate and glufosinate, such as applying persistent herbicides before the crop emerges that will have a continuous effect.[16]

This intense use of glyphosate is leading to new weed control problems which are gradually offsetting the convenience of HT crops. Different weed species are not equally susceptible and shifts are occurring in the composition of the weeds in the fields, towards species that are less affected by the herbicide.[3] In most states with a substantial RR soya acreage, there is also now evidence of weed species developing resistance to glyphosate.[17] These weeds are requiring much heavier applications of herbicides.

The experience in Iowa shows that shifts in weed populations can happen very rapidly. For example, common waterhemp (*Amaranthus rudis*) populations delayed germination and escaped the glyphosate applications. Already in 1997, velvetleaf

4.1 **Key points**

- ★ Herbicide tolerant (HT) crops have been widely adopted as they have reduced the normal constraints on herbicide use
- ★ The claim by the biotechnology companies that HT crops would only require one herbicide application and so reduce agrochemical use has not been realised in practice
- ★ RR soya, RR maize and HT rape appear to be resulting in a greater use and reliance on herbicides particularly after a few years
- ★ A single application has turned out to be impractical as it affected yields; instead farmers are applying herbicide several times in the pursuit of completely 'clean' fields, or applying older and more toxic herbicides in addition
- ★ New weed problems have emerged with HT crops which are leading to a greater need for herbicides
- ★ These include the appearance of more weed species which are less affected by herbicides, weeds becoming resistant to herbicide and HT rape volunteer plants.



(*Abutilon theophrasti*) demonstrated a greater tolerance to glyphosate and farmers reported problems controlling this weed with the rates of glyphosate for which they were willing to pay.[6] In Missouri, where over half the soya crop is GM, farm advisers report that waterhemp has become an increasing problem in recent years. According to them, 2001 was a "fantastic year for waterhemp," with "even good managers being frustrated."[18] In March 2002, farm advisers at the University of Mississippi reported the appearance of resistant horseweed that was requiring a six to thirteen-fold increase in the amount of glyphosate to achieve the same levels of control as normal horseweed.[15]

HT crops also encourage higher agrochemical use because they facilitate "no-till" farming. Traditionally, land is ploughed before the seeds are sown, and this mechanical action kills off many weeds. With no-till farming, however, the land is only at most surface tilled and weeds which would otherwise have been killed by the ploughing are treated instead with heavier applications of herbicide.[19]

There is also the widespread arrival of herbicide resistant oilseed rape volunteer plants in Canada, a serious problem for weed control which is leading to a much greater use of herbicides (this is reported in detail in chapter 7, 'contamination'). HT volunteers and the change in weed population, and resistance, means that in many cases farmers also appear to be reverting to older and more toxic herbicides as a result of HT crops.

Finally, the claims that HT crops would reduce agrochemical use overlooks the fact that many farmers have already begun adopting modern weed control practices which involve a greatly reduced use of herbicides. For example, integrated crop management (ICM) uses specific management practices to reduce weed problems. Organic farmers have taken this approach furthest and do not use any herbicides at all, though they do have higher costs of production as a result.

4.2 Pesticides

Two of the GM crops being grown commercially in North America produce an insecticide in their tissues: Bt maize and Bt cotton. The gene for the production of the Bt toxin was engineered into maize to reduce attacks by two caterpillar pests, the European corn borer and the Southwestern corn borer.[20] In the US, approximately 26 per cent of the total maize area was planted with Bt maize in 2001.[21]

Monsanto claimed that these crops "require less pesticide application."[22] However, overall insecticide applications on maize have slightly increased. Bt cotton has successfully produced a reduced use of insecticides overall, though problems are already being reported.

Bt maize

Despite a significant increase in the area of Bt maize, the area of maize treated with European corn borer insecticide rose slightly from 6.75 per cent in 1995 to 7.3 per cent in 2000, according to Dr Benbrook.[3] The proportion of the total maize area that was sprayed with insecticide for all pests did not decrease, but remained constant over five years at 30 per cent of the total, according to Professor John Obrycki's research team at Iowa State University.[23]

Bt cotton

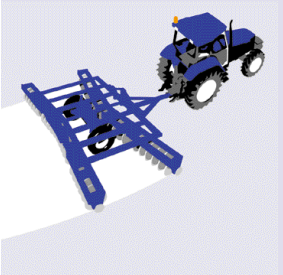
Bt cotton has successfully reduced the overall use of insecticides for bollworms and budworms. The effects, however, have varied widely from state to state, with some having almost eliminated the use of insecticides for these pests and others having almost doubled their use.[24] Reports from the US and other countries (China and Australia) indicate that total insecticide use will increase again due to the development of insect resistance and increases in other pests after a few years.[25, 26]

Why insecticide use on GM maize is up

It should have been clear from the outset that the scope for Bt maize to reduce insecticide use was limited. The European corn borer is only a problem on average one year in five, with many regions each year where it does little damage.[27] Moreover, although insecticides alone do not provide full control in an outbreak,[17] modern integrated pest control methods can achieve adequate control through specific management practices and targeted use of insecticides. Organic farming relies almost fully on alternative pest control practices and only uses very few insecticides, such as natural Bt, as a secondary means of control.

4.2 **Key points**

- ★ Bt maize has been genetically engineered to continuously produce the insecticide, Bt toxin, in its tissues
- ★ It was claimed that Bt crops require less insecticide use, but the maize area sprayed has not decreased and the amount of chemical applied has slightly increased
- ★ Bt maize can only control the European and the Southwestern corn borer, so farmers are stillapplying insecticides for other insect pests
- ★ Bt cotton has so far successfully reduced the overall use of pesticides, though the development of insect resistance is likely to lead to increased use in future
- ★ To prevent the development of insects resistance to Bt, maize farmers are advised to grow no more than 50–80 per cent of their total maize area to Bt maize
- ★ The development of resistant insects could render Bt crops redundant and undermine the less intensive use of natural Bt by organic farmers.



Bt crops can also only resist the specific pests for which they were designed, so for many farmers there is still a need to apply other pesticides. Professor Obrycki's team concluded, in a review in *Bioscience* in 2001, that the use of Bt maize would not significantly reduce insecticide use since "Bt plantings are not being used as a replacement for insecticides, but in addition to them."[23] In addition, the effects of Bt maize are limited by the fact that farmers are restricted to planting no more than 50–80 per cent of their total maize area to Bt maize by the US Environmental Protection Agency (EPA).

The general consensus for why insecticide use has increased with the introduction of Bt maize is that all the academic and industry focus on Bt maize and the European corn borer has led farmers to become more aware of their insect problems, including other pests such as armyworms. Insecticide use has gone up for all of these insects, including European corn borers.[17]

Pest resistance and 'refuges'

One problem with Bt crops is that they will encourage insect pests to become resistant to the toxin. This would not only bring the point of Bt crops to an early end, but it would undermine organic production systems.

Bacillus thuringiensis (Bt) is a naturally occurring bacteria which has long been used as a highly selective biological control agent against caterpillars in organic farming. The spores are applied in spray form when the need arises. According to a survey by the Organic Farming Research Foundation, organic growers in the US use Bt sprays more than any other product to manage insect pests; over 50 per cent use Bt frequently or occasionally.[24]

Although Bt has been used for a long time, the risk of pest resistance developing has been considerably inflated by the introduction of Bt crops. Bt toxin in GM crops is different from the use of natural Bt. Natural Bt is only applied occasionally and degrades within three days. The engineered Bt genes, however, unlike naturally occurring genes, are active the whole time and throughout the plant, so Bt crops produce the toxin continually in all their tissues. The Bt gene is also being engineered into several different crops at the same time. In response to such constant and widespread exposure, only insects with a natural immunity to the toxin are expected to survive and form the basis of a resistant population.

To address this problem, the Bt maize sector and the EPA have instigated insect resistance management plans "to preserve the benefits of this technology for years to come."[28] However, this has introduced major practical constraints on farmers who wish to grow Bt crops. The plans require farmers in the maize belt to plant at least 20 per cent of their total maize area to non-Bt maize varieties and farmers in southern states of overlapping maize and cotton production to plant at least 50 per cent to non-Bt varieties.[28] There are guidelines for how this should be done.[29]

The idea is that these Bt-free 'refuges' will maintain a population of susceptible insects for mating with Bt resistant insects, and so prevent the resistant insects from becoming dominant. Clearly, this practical restriction undermines the supposed convenience of Bt crops, and a biotechnology industry survey published in January 2001 found that nearly 30 per cent of farmers who grew Bt maize in 2000 were not following the resistance management guidelines.[30]

Moreover, research suggests that the rate of build up of resistance has been underestimated. The refuge plans were developed on the assumption that the inheritance of the Bt resistance trait would be recessive and thus slow to evolve. But research published in *Science*, in 2000 by Kansas State University shows that the inheritance of resistance may be "incompletely dominant," meaning that resistance may develop faster than originally predicted.[31]

"GMOs do not provide a quick fix solution to the economic problems of US farmers. As time goes on the technology is proving to be more of a hindrance than a help."
John Kinsman, vice-president of the National Family Farm Coalition and dairy farmer in Wisconsin[1]

5 Farmer income

"There's profit in your fields. Unleash it with Asgrow Roundup Ready soybeans … With Asgrow soybeans, profitability runs wild."
US farming magazine advert, January 2002[2]

The widespread introduction of GM crops in North America was achieved through promises of higher profits for farmers. Many farmers were in a desperate economic situation and ready to believe that GM crops could help them into a better financial state.

However, the reality has been that GM soya and maize have worsened the situation. The results differ between regions and from year to year, but overall the effect of these crops on farm incomes has been negative. Feedback from farmers and independent economic analysis of the data from six years of commercial growing show that these two GM crops deliver less income on average to farmers than non-GM crops. Furthermore, those farmers producing GM-free produce have been able to command price premiums for their produce that, by definition, GM farmers cannot access.

This section looks only at the direct impact on farmer income of GM crops (the indirect impacts of GM crops on the wider farm economy are addressed in chapter 10).

HT soya

Analysis by Iowa State University economist Michael Duffy has shown that, when all production factors are taken into account, herbicide tolerant GM soya loses more money per acre than non-GM soya. GM soya lost $8.87/acre while non-GM almost broke even, losing $0.02/acre.[3] This was based on a conservative five per cent estimate for the extra cost of the GM seed technology fee, and assumed the same market price for GM and non-GM soya, in other words the differences are likely to have been underestimated.

Bt maize

In a December 2001 report, Dr Charles Benbrook presented the results of a detailed analysis of the economics behind Bt maize. The profitability of Bt maize is variable; it is also hard to predict in advance as it depends on the level of pest problems. On an annual basis, the Bt varieties paid off on average in three of the years they were grown (1996, 1997, 2001), but not in the other three (1998, 1999, 2000). Over the whole period the outcome was negative: "From 1996–2001, American farmers paid at least $659 million in price premiums to plant Bt corn, while boosting their harvest by only 276 million bushels – worth $567 million in economic gain. The bottom line for farmers is a net loss of $92 million – about $1.31 per acre" from growing Bt maize.[4]

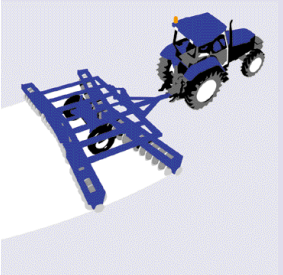
Duffy undertook a similar analysis on Bt maize. He also found little economic evidence to account for the rapid uptake of the GM variety. Returns per acre from Bt maize were slightly worse, with Bt maize losing $28.28/acre and non-Bt maize losing $25.02/acre.[3]

HT rape

There is a scarcity of independent research on the economics of growing HT rape. However, one industry study of rape growers suggested that while the herbicide use of those growing HT rape was higher, farm

5. **Key points**

★ Contrary to the industry claims, GM crops have reduced average farm profitability
★ HT soya reduced average returns by about $8.8/acre compared to non-GM soya
★ Bt maize reduced average returns by about $1.3-$3.2/acre compared to non-Bt maize
★ GM seeds are significantly more expensive than non-GM seeds as farmers have to pay a technology fee which adds 25–40 per cent to seed costs and prevents them saving seed
★ A significant fall in herbicide prices has offset the cost of the greater use of herbicides for HT crops
★ GM crops are receiving lower market prices than those available for non-GM crops; guaranteed GM-free crops are obtaining significant price premiums.



incomes were slightly higher due to higher yielding varieties, lower herbicide costs and lower fuel costs.[5] The Canadian government's Biotechnology Advisory Committee said "As of January 2001 there is no publicly available survey or data on how individual farmers have benefited from the adoption of GM crops in Canada."[6]

Why farmer incomes are down

The differences in income that a farmer will receive from growing GM crops compared to non-GM crops results from four factors, covering both higher production costs and lower market prices:

- *The technology fee for GM seed*
  Seeds are an important cost of production. For example, they typically account for about 10 per cent of total maize production costs.[7] GM seeds are significantly more expensive than non-GM seeds because the biotechnology companies charge an additional 'technology fee' on top of the seed price. Monsanto describes this as a way that growers can "share a portion" of the extra profits that the crops will deliver.[8] The scale of the fee can vary greatly depending on the crop, the company and the particular package on offer.

  With the technology fee, GM seeds cost 25–40 per cent more than non-GM seeds.[9] For Bt maize, for example, the fees are typically $8–$10/acre, about 30–35 per cent higher than non-GM varieties, though they can be up to $30/acre. RR soya can have a technology fee of about $6/acre.[4, 10]

  To buy GM seeds, farmers also have to sign a technology agreement with the biotechnology companies. This contract prohibits the farmer from saving seed (retaining a proportion of the harvest for planting the following year). With approximately 20–25 per cent of farmers traditionally saving their seed in the US, this prohibition introduces another seed cost for these farmers.
- *Yield differences*
  The biotechnology companies claimed that the higher costs would be more than offset by the higher yields and reduction in agrochemicals. However, RR soya and RR rape produced lower yields than non-GM varieties on average, and although Bt maize produced a small yield increase overall, it was not enough over the whole period to cover the higher production costs (see chapter 4).
- *Agrochemical costs*
  Agrochemicals make up a large proportion of farmers' production costs. RR soya, RR maize, Bt maize, and HT rape have mostly resulted in an increase in agrochemical use. However, because of a herbicide 'price war' that has erupted in the US, herbicide costs have fallen significantly since the introduction of GM crops. In many cases it has meant that total herbicide costs have significantly reduced. Soya herbicide prices, for example, have fallen over 40 per cent since the introduction of RR soya in 1996. This has greatly helped to offset all the higher costs of RR soya (the price of seed, the yield drag and higher agrochemical use).
- *Lower market prices*
  Farmers did not bargain for the negative effect that GM crops have had on market prices (see chapter 10). Since the introduction of GM crops a tiered market has developed. Farmers growing GM crops now receive lower market returns than previously, and also lower prices than those growing non-GM crops. The income calculations by Benbrook and Duffy did not take this into account.

  For those growing non-GM crops, market premiums are available to offset the fall in market prices. According to a survey of 1,149 grain elevators in 11 Midwestern US states by the American Corn Growers Association last autumn, almost 20 per cent are offering farmers premiums for non-GM corn and soya ranging from 5–35 cents per bushel.[11]

  The farmers who have gained in terms of market prices are those who can supply guaranteed GM-free produce, for the growing 'identity preserved' (IP) markets which have developed since the introduction of GM crops. For example, according to Minnesota farmers Susan and Mark Fitzgerald, GM-free soya receives around 50 cents/bushel more than GM, selling at $4.40/bushel (approximately a 13 per cent increase) and organic soya sells at $12/bushel, an additional premium of 200 per cent.[12]

While there are some farmers growing GM crops who have been able to cut their production costs or increase yields with GM crops, it appears that, for most producers, any savings have been more than offset by the technology fees and lower market prices, as well as the lower yields and higher agrochemical use of certain GM crops.

"GM canola has, in fact, spread much more rapidly than we thought it would. It's absolutely impossible to control … It's been a great wake-up call about the side effects of these GM technologies."
Professor Martin Entz, University of Manitoba, 2001[1]

"Farmers in this province are spending tens of thousands of dollars trying to get rid of this canola that they didn't plant. They have to use more and more powerful pesticides to get rid of this technology."
Professor Martin Phillipson, 2001[2]

6 Herbicide resistant volunteers

Among the new set of problems that GM crops have brought, the arrival of herbicide tolerant (HT) volunteers and 'superweeds' emerges as a serious problem for farmers who try growing GM crops.

Unless the farmer has decided to keep growing the same crop on the same piece of land forever, there is always the issue of dealing with 'volunteers' – plants appearing that were planted in previous seasons and failed to germinate then or grew from spilt seed from the previous crop. Normally, these are dealt with in the same way as other weeds, with a herbicide. But as North American farmers are finding, if the previous crop was an HT crop, the volunteers will not always be controllable with the preferred herbicide because of their resistance to it.

When one looks at GM HT fields after harvest, the inevitability of this problem is clear. Michael Alberts from Marquette, Nebraska had planted Roundup Ready soya in 2001. The ground was still littered with stubble and beans from the previous harvest when visited in January 2002. He accepts that he will have to use another herbicide to clear the field before he can start planting his next crop.

Many farmers are now facing HT volunteer problems. Percy Schmeiser, a farmer from Saskatchewan who has had well publicised problems with GM rape, said "I've had at least 100 farmers across the west telling me about problems they're having with volunteer canola."[3] In Manitoba last year, farmers even experienced HT volunteer rape plants growing past the stage at which they could be controlled.[4]

In response, Monsanto have started to send groups of students into the fields in some areas to remove the volunteer plants by hand - certainly a contrast to the high-tech, sophisticated impression of GM farming given in the advertisements. The company said that they were making every effort to satisfy producers who find "unexpected volunteers" in their fields. However, it is clear that Monsanto expects GM rape farmers to be faced with resistant volunteers for some time. "They tell me the seed can sit dormant for up to five years" said Ken Howell from Birsay, Saskatchewan. "This is only the second year and it sounds like there is still some seed out on my fields that didn't get cleaned up."[5]

All HT crops pose the risk of this problem, but HT oilseed rape has emerged as particularly risky. It is a relatively primitive crop, retaining many characteristics of wild species. One of these is that the seedpods mature unevenly, and so farmers cut the crop to allow it to dry prior to combining. Upon maturity, the dry pods shatter dropping a fraction of seed on the ground, which will germinate later. Moreover, rape

Chris Dzisiak

Chris Dzisiak from Dauphin, Manitoba, planted a 156 acre field to Roundup Ready oilseed rape in 1999. He has described this action as giving him one year of gain and three years of pain. The following year he planted the field to wheat. He had Roundup Ready oilseed rape volunteers that he had to control with the far more toxic herbicide 2,4-D. But in 2001 the problem became more acute. He applied a 'pre-seed burn-off', to chemically clear the field of weeds prior to sowing, and planted the field to flax. But when it became apparent that the burn-off had failed to control the Roundup Ready volunteers, he was forced to apply a further herbicide mix. While this killed off the volunteer weeds, his flax crop was also affected, resulting in a yield loss of three bushels/acre.

Dzisiak estimates that he lost $4,500 in 2001 and he expects to have problems in 2002 with more herbicide tolerant oilseed rape pushing its way into his crop of peas. His experience has left him sure that he will never grow a Roundup Ready crop again. "I certainly didn't save myself any money and I certainly didn't save myself any time."[10]

Michael Alberts

Michael Alberts from Marquette, Nebraska had planted Roundup Ready soya in 2001. The ground (pictured below) was still littered with stubble and beans from the previous harvest when visited in January 2002. He accepts that he will have to use another herbicide to clear the field before he can start planting his next crop.

seeds can lie dormant for up to 10 years, so there is the risk that the crop will be contaminated with volunteers for years to come.[6] Oilseed rape is also known to pollinate wild mustard, creating another genepool that can store and re-distribute the resistance traits.[7]

Multiple resistance – 'superweeds'

There are now GM HT rape varieties which are separately resistant to three different herbicides, being grown commercially in North America. One of the early scares about GM crops was the potential that they might create 'superweeds'. The fear was that through cross pollination, the trait for herbicide tolerance would either move into populations of related weed plants, making them harder to control, or that through successive generations herbicide tolerance traits from different GM varieties would combine, 'stacking' the genes for tolerance to a number of different herbicides in one plant.

The biotechnology industry had repeatedly dismissed such concerns. When asked about superweeds, Monsanto directed enquiries to The Council for Biotechnology Information, a GM industry funded organisation. In February 2001, this stated that new research findings "dispel fears that biotech plants will become superweeds, either in their own right or by breeding with unmodified plants."[8]

But Tony Huether's experience (see facing page) shows that gene-stacking was already a problem in 1998, two years after GM HT rape was first grown in Canada. And his case is far from unique. In 1999, Agriculture Canada, part of the Department of Agriculture and Agri-food, found gene stacking in all of the 11 locations it investigated where Roundup Ready and Liberty Link crops were growing in adjoining fields.[9] Weed scientists now suspect that the occurrence of volunteers with 'stacked' herbicide tolerant genes is common in the Canadian prairies.[11]

In field trials, University of Idaho researchers have confirmed that multiple resistance develops at a very fast rate. Through field trials they found that oilseed rape plants can acquire three herbicide tolerance genes – for glyphosate, glufosinate and the imidazolinones – in just two years. They also identified hybrids of oilseed rape and weed species containing two herbicide tolerant transgenes.[9]

Nevertheless, there is no monitoring

of the exact extent to which multiple resistant volunteers are emerging. In the US, the problem has not yet arrived as the commercialisation of GM rape was only allowed in 2001 and then only for two regions.[9]

Multiple-resistance is a result of gene transfer between different HT varieties. As with single-gene resistance, multiple-resistance is a particular problem with oilseed rape. As well as the problems of the seed shattering, the length of dormancy and related weed species, oilseed rape produces very small, round, smooth seeds that travel considerable distances in the wind. Experiments carried out by the government in Saskatchewan showed that pollen from GM oilseed rape travels much further than expected, at least 800 metres. This is eight times the official Canadian separation distance for pedigree seeds of 100 metres.[12] In the UK just a 50 metre separation distance is officially advised between GM oilseed rape and conventional non-GM varieties.[13]

Why HT volunteers increase herbicide use

The main problem for farmers of GM HT crops is that they cannot rely on their normal herbicide, and end up spending extra time and money trying to deal with the problem. This is harder if the plants are multiple-resistant, but the farmer will not know this until different herbicides have been tried.

Another worrying outcome appears to be the return to older, more toxic herbicides, such as paraquat and 2,4-D, the very chemicals that GM crops were supposed to render obsolete. Paraquat is a notoriously toxic herbicide, described by Oxford University's Chemistry Laboratory as "very toxic by inhalation, ingestion and if absorbed through skin." It is also a possible mutagen and carcinogen, and may be fatal if swallowed, inhaled or absorbed through the skin. It is very destructive of mucous membranes and causes burns.[14] 2,4-D is also exceedingly toxic; it was a component of Agent Orange, the mutagenic effects of which are still being suffered by a third generation of Vietnamese (Agent Orange was used in the chemical warfare attacks on Vietnam in the 1960s).[18] These chemicals should now be obsolete, yet it seems that in North America the commercial growing of GM crops is reviving their use.

Another concern to farmers is that HT volunteers have the potential to lock farmers

Tony Huether

Tony Huether farms in northern Alberta. In 1998 he noticed some oilseed rape in a field he wanted to use for wheat. He used Roundup, but this failed to kill the plants. Realising it was probably a relict of the GM 'Quest' oilseed rape he had planted the previous year, which is tolerant to Roundup, he tried a different herbicide, glufosinate. This also failed to have an impact and he knew he had a problem.

Specialists from Alberta Agriculture, the state agriculture department, took samples of Huether's plants. They confirmed what he suspected, that the plants had genetic resistance to two herbicides – glyphosate and glufosinate. They also found that seed from the fields produced plants resistant to not just these herbicides, but to a third herbicide as well, imidazolinone, to which there is also a rape variety that is resistant.

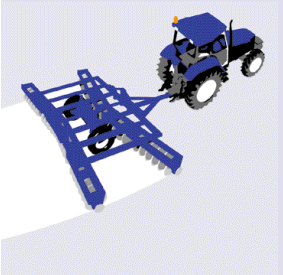
How this came about can be explained by looking at the crops that Huether had grown the year before. He had planted Monsanto's Quest oilseed rape tolerant to glyphosate in one field. Across the road he planted 20 acres of Innovator, a GM rape tolerant to Aventis's Liberty herbicide glufosinate.[15] And the rest of the same field went to 120 acres of another GM variety, this time tolerant to Cynamid's Pursuit and Odyssey herbicides (imidazolinones).[16]

A team from the University of Alberta investigated the possibility that this was the result of random mutations. But their results showed clearly that it was the result of cross pollination between the different GM HT varieties. "DNA analysis of the seedlings indicated contributions from more than one resistant parent, clearly indicating that the multiple resistance had arisen from pollen transfer, rather than mutation. Evidence is consistent with resistant gene movement via pollen flow from one field to another."[17]

To deal with these plants Huether had to turn to the exceedingly toxic herbicide 2,4-D. Huether's case has served as a warning for the risks that GM crops bring. "I've had my fill of being controlled by large companies" he said. "Monsanto led us to believe that this kind of thing wouldn't happen. There were no warnings until they were made aware of what happened on my farm."[15]

6. **Key points**

- ★ HT rape has created a widespread problem for Canadian farmers as some of the plants are emerging in following years as herbicide resistant volunteer weeds
- ★ In many locations, cross-pollination between different HT varieties has produced volunteers resistant to several herbicides – multiple-resistant volunteers
- ★ Oilseed rape is a particular risk among HT crops, as the seeds are scattered by the seedpods and remain dormant for up to 10 years
- ★ Farmers are resorting to applying several different and more toxic herbicides in their attempts to eradicate the plants
- ★ In some areas Monsanto has sent in students to remove the rogue GM plants by hand
- ★ Monsanto has now taken out a patent for general mixtures of herbicides, to control GM weeds with multiple resistance or different GM weed species. This will restrict farmers from making their own mixtures to control volunteers in the future.



into GM production. If a GM farmer decides that he wants to return to non-GM crops and he has HT volunteers, he may have a problem supplying GM-free markets. Also the very presence of these patented plants on his land is a liability, as they might be perceived as a legal infringement of a company's technology use agreement (these issues are explored more in chapters 7 – under 'contamination' – and 11 – under 'legal issues').

It seems Monsanto does not intend to send out hand-weeders for much longer: the company has seen a commercial opportunity in HT volunteers. In June 2001, it took out US patent no. 6,239,072 for general mixtures of different herbicides. Extraordinarily, this covers the relatively straightforward process of mixing herbicides, and not just of pre-made mixtures but apparently also mixtures made by farmers themselves from herbicides they would already have paid for, called tank mixtures. The abstract states:

"The present invention is directed to tank mixtures and premixtures of a glyphosate herbicide and a second herbicide to which a first species is susceptible and a second species is resistant. Such tank mixtures and premixtures allow control of glyphosate-susceptible weeds and glyphosate-tolerant volunteer individuals of the first species in a crop of glyphosate-tolerant second species with a single application of herbicide."[19]

The patent will enable the company to profit from a problem that its products had created in the first place, it will make it even more difficult and expensive for farmers to control HT volunteers.

Superweeds are a reality

The prospect of superweeds was raised by scientists as early as 1985, when the concerns were focused on the weed population.[20] Original and literature research by the University of California on a wide range of crops during the 1990s, confirmed that the outcrossing of crop plants with wild relatives "appears to be a general feature of most of the world's important crops," suggesting that weeds could indeed become a problem with HT crops.[21] Six years after the introduction of GM HT crops in North America, it has emerged that the HT crops themselves are a severe weed problem for farmers.

In a review of the Canadian experience with oilseed rape, English Nature, the UK government's advisory body on biodiversity, concluded, "it is accepted that gene stacking of the three most commonly grown HT crops (Roundup Ready, Liberty Link, Clearfield) can readily occur in practice." They went on to predict that "herbicide tolerant gene-stacked volunteers of oilseed rape would be inevitable in practical agriculture in the UK" and that "separation distances between non-hybrid crops will only have a small impact on [multiple resistance] occurrence unless the isolation distances are increased to 400 metres or more."[9]

"GMOs can play havoc with speciality commodities because of pollination drift and contamination as well as contamination of the seed supply … This raises the question of whether conventional commodities and GMOs can realistically co-exist."
Dan McGuire, policy chairman,
American Corn Growers Association, 2002[1]

7 Contamination

The single greatest problem that GMOs have caused in North America is the widespread contamination of the agricultural and food sector. It has happened within a few years of the commercialisation of GM crops and has occurred at all levels of the food chain, from seed and crop production to food manufacturing.

This contamination has had many serious economic and legal consequences, and has been the most significant problem for farmers. GM contamination has caused many farmers to change their minds about GM crops.

Contamination has had a massive impact on farmers who are trying to avoid genetically engineered crops. Where GM crops have been commercialised, contamination means GM-free seed stocks are now difficult to purchase and supplying GM-free and organic markets has become an economic risk as well as an agricultural challenge. In many areas, seed companies and organic farmers have been forced to stop growing certain crops.

Contamination has also impacted on the industry at large by disrupting food processing and undermining the trading of commodities. Contamination has also led to many wider problems affecting farmers' independence, agricultural markets, farm prices and legal liabilities.

There are three main areas where contamination occurs:

- Seed production
- Crop production
- Commodity trading and food processing.

7.1 Seed contamination

"When a genetically engineered (GE) variety is introduced in a region, it makes it extremely difficult to grow a certified organic crop of the same species because of seed stock contamination, seed movement and pollen drift. Canola is the Saskatchewan example; elsewhere it is corn and soybeans."
Presentation by Saskatchewan Organic Directorate to the Canadian House of Commons, 2002[2]

The contamination of North American seed resources has become a serious nationwide problem. It has affected those trying to produce GM-free seed and crops, and even the companies trying to produce GM seed. It has particularly affected organic farmers.

The US organic certifier Farm Verified Organic has stated that GM contamination of maize, oilseed rape and soya is now so pervasive that they believe it is no longer possible for farmers in North America to source GM-free seed.[3] The Canadian Seed Trade Association believes that all non-GM varieties of crops, where GM varieties are available, are contaminated with an average of one per cent GM seed.[4]

Due to the difficulties in obtaining seed, organic and GM-free production of soya, maize and rape has become very difficult in many areas. The problem is particularly acute in Canada, where contamination is so widespread in the rape sector that most organic farmers have had to give up growing it altogether. In a submission to the courts in January 2002, a group of organic farmers from Saskatchewan stated, "The contamination has reached a level such

Testing methods

- ELISA (enzyme-linked immunosorbent assay) or 'strip-test'- the most rapid test available, taking just five minutes. However, each test kit can only test for one GM 'event'. This test is used by farmers and at specialist grain elevators
- Herbicide bioassays – these detect the presence of herbicide tolerant traits; they cost $20–$30 and take up to a week as seedlings have to be grown and tested
- PCR (polymerase chain reaction) – the most accurate and expensive test, and the only one which can indicate the percentage of GM material present; it takes up to three days and costs $300 a sample.

that very few, if any, pedigreed seed growers in Saskatchewan will warrant their canola seed to be GMO-free"[9] Ian Cushon, an organic farmer, in Oxbow, Saskatchewan said, "We don't grow canola … there were organic farmers growing it and most have dropped it as it is nearly impossible to get clean seed."[10]

Seed contamination is also a concern for the maintenance of crop genetic resources. The Northern Plains Sustainable Agriculture Society (NPSAS), for example, is disturbed that the genetic status of 'foundation seedstocks' has become compromised. Foundation seedstock programmes are designed to maintain, increase and distribute genetically pure seed of established and new cultivars. But in March 2001 the NPSAS found that the North Dakota State University, one of the participants in the programme, was running Roundup Ready wheat trials next to its seedstock plots. The University responded that "There can be no guarantee that GMO DNA has not been introduced (into the seedstock plants)."[11]

Even Monsanto has admitted that complete genetic purity is now unattainable. According to spokesperson Trish Jordan "zero per cent – that's impossible." She gave the reason as "the sophistication of seed testing methods now. You can get down to 0.1 per cent of something."[12]

As seed is the starting point of the whole food chain, contamination at this stage is particularly undesirable. Moreover, official standards for commercial seed production have always required very high levels of genetic purity in order to ensure that a farmer's seed supplies are not contaminated with other varieties. GM contamination should not be an exception. Foundation seeds, for example, are grown directly from breeders' seed and should be in their purest form. In Canada, the seed standard for foundation stock of oilseed rape allows no more than 0.1 per cent contamination by other varieties. However, due to the rate of gene flow from commercial GM crops, seed breeders are now having to accept that it may be impossible to continue producing hybrid seed varieties in Canada that meet the seed standards.[13]

How seed becomes contaminated

During the breeding and production of seed, GM contamination can occur by gene transfer, accidental seed mixing or the use of soiled machinery. Gene transfer occurs

Advanta oilseed rape

In May 2000, it was discovered that a large quantity of Canadian non-GM rapeseed which had been exported to Europe was contaminated with a transgene that was unapproved in Europe (GT-73, from Monsanto's Quest rape). This led to the destruction of thousands of acres of rape and compensation payments by the seed company Advanta to the farmers involved.[5]

The inquiry set up by the Canadian government to look into the incident reported on 15 February 2002. It found that though the seeds had been grown over 800 metres from any other GM crops, in accordance with Canadian regulations, three-quarters of the final seeds lots had been contaminated,[5] at levels of up to 2.6 per cent.

The inquiry did not decide on the cause of the contamination. Advanta, however, was convinced that it was due to cross-pollination and after the incident the company moved its commercial seed production from western Canada to New Zealand, eastern Canada and Montana, to ensure GM-free purity of their future seed supplies.[6]

Monsanto's GM Quest rapeseed

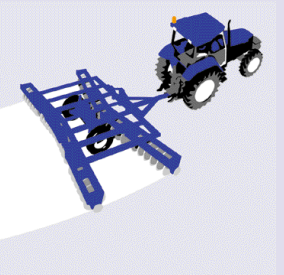
In May 2001, Monsanto discovered GM contamination of their GM variety, Roundup Ready Quest oilseed rape. This rape contains the GT-73 gene, but they found it also contained GT-200, another Roundup resistance gene developed by Monsanto but not approved for release.[7]

Around 3,000 farmers had already bought the seed when they found out and the discovery resulted in an immediate recall of the bags purchased. At the time Monsanto said the incident was evidence that their quality control system worked. A year later, however, it said it was concerned that contaminated seed could turn up in the food chain and announced that it was trying to get GT-200 licensed so that it would not disrupt trade.[8]

According to the *Western Producer* newspaper when the discovery was made "By demonstrating its gene control system is susceptible to leaks, Monsanto threatens to scare away Canada's major canola buyers, just as StarLink, developed by Aventis, scared buyers from American corn products."[7]

7.1 **Key points**

- ★ North American soya, maize and rape seed resources have become almost completely contaminated with GMOs
- ★ Contamination of seeds with unapproved transgenes has caused costly recalls of non-GM and GM seed
- ★ Farmers wishing to grow organic or 'identity preserved' crops are having to make special sourcing and testing arrangements for their seed
- ★ Most organic farmers in Saskatchewan, the main organic farming province in Canada, have had to stop growing oilseed rape as it is almost impossible to find GM-free seed
- ★ Seed contamination results from cross-pollination, accidental seed mixing and contaminated machinery.



by cross-pollination: pollen can be transported over very large distances in any direction by wind or insects. Bees, for instance, regularly fly up to three miles. Cross-pollination can therefore readily occur when new seed varieties are bred and tested in fields or during the multiplication process to build up the seed stocks. While the use of separation distances reduces the risks, they are never large enough in North America to guarantee zero contamination at the end. The machinery used for harvesting also allows the possibility of contamination. If the combine has harvested GM seed in the past, then unless there is thorough cleaning, it is not possible to guarantee zero contamination.[14]

Because of the level of seed contamination, organic or IP farmers who succeed in finding a GM-free seed source are being advised to obtain statements from the seed companies declaring the seed to be GM-free. Once the seeds arrive, the farmers are also advised to test them for all potential transgenes. Home test-kits are available, but most are 'strip-tests' which only indicate the presence of a specific GM trait, so several tests need to be done on each seed lot. But even this does not guarantee zero GM contamination, as the only traits that can be tested for are those for which test kits have been released by the biotechnology companies.

In 1997, the Canadian seed company Limagrain was producing RR rape that was found to contain the wrong gene, requiring the seed to be recalled from the market. Limagrain did not have the ability to test for the genes, as Gary Bauman, sales and marketing manager explained: "The apparent contamination, discovered by Monsanto, is something only they are able to detect. We are not even allowed to try to investigate how to look at and discover this gene within our own varieties."[15]

7.2 **Crop contamination**

Farmers across North America are facing major difficulties keeping their growing crops free from contamination. In the main GM crop growing areas, non-GM farmers have their business choices to a large extent controlled by what their neighbours are growing. Even when they have obtained GM-free seed, organic farmers who try to grow organic crops for which there are GM varieties are having to go to great lengths to avoid contamination. Farmers whose crops have become contaminated have lost money, and many organic farmers have given up trying to grow certain crops.

In Canada, contamination of the oilseed rape crop has reached such a level that most organic farmers in Saskatchewan, the province with the most organic farming, have given up growing rape. They have taken their complaint to court (see chapter 11, 'legal issues'). In a statement they said: "Few, if any, grain farmers in Saskatchewan could warrant their canola crop, even if planted with GMO-free seeds, to be free from GMO contamination."[22]

In the US, the situation is not quite so severe as in Canada, as GM oilseed rape has not been widely introduced. However, contamination still seems to be widespread. This is indicated by the levels picked up by the specialist organic and IP grain elevators, which are supplied by those farmers who are trying to produce GM-free. The grain elevators are where seed is first taken from farms; the specialist ones test their deliveries regularly for contamination. SK Foods International is one such specialist elevator, operating at Fargo, North Dakota. The level of contamination in the area is high enough for the company to have to test every delivery. Around five per cent of loads have to be turned away due to GM contamination. Crop production manager Derek Crompton is concerned about the future: "It will be almost impossible to get 100 per cent GM-free corn and when they introduce GM wheat … it doesn't take a rocket scientist to realise that pollen travels."[23]

Earthwise at Moorhead, Minnesota, is another specialist organic and IP elevator, established in 2000. At busy times they handle up to 23,000 bushels a week. Before farmers are allowed to deposit their crops, the load is tested. Currently about one in every fifty loads, two per cent, is found to be contaminated. The contaminated loads are turned away.[24]

While the ultimate controls on GM contamination of organic produce are through the marketplace, the organic certifiers are limiting the risks in the organic farming system by operating a 'systems based' approach to contamination through their certification process. This means that the farmers are required to follow specific practices to reduce the risk of contamination, as opposed to the use of purity standards for their produce. The details of the approaches vary from certifier to certifier. In addition, during their inspections, some *(continued p 32)*

Tom and Gail Wiley

The Wiley family has farmed around Montpelier, North Dakota, for over 100 years. Tom and Gail still run it very much as a family farm, working with their son Paul. Of the 3,000 acres, approximately 1,000 are given over to soya each year. GMOs were offered as a way to achieve 'no-till' farming but Tom said "I have never been sold on no-till. Tried it but didn't get good results. I am a conventional non-GMO farmer. I have not seen any reason to go the GMO route. Anyway, the system they touted seemed 'too good to be true' – and that is enough to make anyone suspicious."

But Tom's desire to produce non-GM soya was taken out of his control. In 2000, he landed a good contract for 15,000 bushels of food grade soya for Japan. This required him to "jump through loads of hoops – everything had to be the right size, colour and protein content." Tom was just about to deliver on the contract when he was told that there was a problem. The agent had found 1.37 per cent contamination with GM material. The test was repeated and found to be correct. He lost the contract, and with it around $10,000.

This all happened as Tom and Gail were taking their concerns about the potential damage the introduction of GM wheat could have on the state's economy to the North Dakota state legislature. They were arguing that, as wheat was the state's largest crop, it would be irresponsible to endanger the sector without further testing. They lost their case, found that their own soya was contaminated, and became committed anti-GM campaigners.[16]

Marc Loiselle

Marc Loiselle, from Vonda, Saskatchewan, describes himself as the "steward of an intergenerational family farm" and has been farming organically for 17 years. He grows hard red spring wheat, barley, oats, flax, peas, alfalfa and clover.

He received inquiries from an Asian buyer for organic oilseed rape offering C$18/bushel compared to the conventional rate of around C$7/bushel. But he knew it would be impossible to keep his crop free from GM contamination during the growing season because of the nearby GM oilseed rape fields.

If he had taken up the contract, Marc would have sown 130 acres to canola. He estimates that with the drought conditions at the time he would have had a yield of around 12 bushels/acre. This would have meant an income of some C$28,080. In the end he had to plant barley, which earned him C$4,160 some C$23,920 less.[17]

Marc is now hoping his losses will be compensated through a class action by the Saskatchewan Organic Directorate (see section 11.2).

Sue and Mark Fitzgerald

The Fitzgeralds farm 1,400 acres of maize and bean (soya and edible) in rotation in Hancock, western Minnesota. They converted to organic farming in 1998.

Last year one of their 100 acre fields of maize had a neighbour's crop of Bt maize to its east. To reduce the risk of contamination, they had planted hedges and bought maize seed guaranteed to be free of GM contamination. Sue and Mark started to harvest from the west, and when they got to the mid-point of the field, they started testing each 200 bushel load with strip-tests before transferring it to the silos. "When we got to 180 feet of the border, we began to pick up contamination," explained Sue. "The contamination was all along the side up against the neighbours Bt maize field. We lost around 1,000 bushels from the total field harvest of 12,000 bushels." They sent the contaminated maize straight off to the elevator as a non-organic crop.

This loss of around eight per cent of the organic crop cost the Fitzgeralds' almost $2,000. They were getting $4/bushel for the organic crop, and only $2/bushel for the contaminated grain.

According to Susan, it could have been much worse. "If there had been a Bt crop to the north west, it might have taken out the entire crop, as that is where prevailing wind comes from.

"All we can do is try and run our rotation with our neighbours, so if they grow corn, we grow beans. But they also need to put up a refuge – they sign a statement committing to putting one in, but farmers often say that they don't know what they have signed."[18]

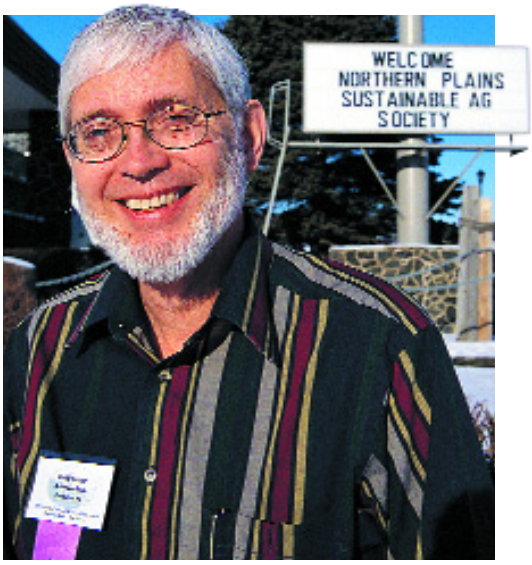
Roger and Amy Lansink

Roger and Amy Lansink farm nearly 500 acres in Iowa. They are certified organic and grow maize, soya, barley, oats, alfalfa, rye and some squash. They also raise cattle, sheep and chickens.

In spring 2001 they planted organic soya seed. Roger was very careful: before ordering the seed he paid for a test and received a certificate stating that there was zero per cent GM content. He had a sample sent to him which he tested and found to be clear of contamination, so he ordered his seed. When this arrived he tested it and again found that it was clear. Just as he was about to plant the seed he noticed some of the beans looked a little different so he had them tested for a fourth time. They were fine as well.

In autumn 2001, Roger and Amy sent their harvest to Clarkson Grain (Illinois), with whom he had a contract to supply. But they told him that their testing had found GM contamination. They are now waiting for confirmation of this – if it is true they could lose at least $40,000 ($10.50 contracted price per bushel for organic, vs. $3.85 as the conventional price at the elevator).[18]

"The buyers are now looking for a feed market that doesn't do the GMO testing. They are starting to think that they got a bunch of bad tests, or they didn't quite do them right, as they have had a lot of soybeans come up GMO positive last fall."[20]



Earthwise

A Minnesota-based specialist organic and IP elevator, handle up to 23,000 bushels a week. Before farmers are allowed to deposit their crops, the load is tested. Currently about one in every fifty loads, two per cent, is found to be contaminated. The contaminated loads are turned away.

David Vetter – The Grain Place

David Vetter (above) has been running his 280 acre farm in Marquette, Nebraska as organic since 1977. In 1998 he became aware of neighbours growing GM crops, so he began a process of testing to ensure the integrity of his maize. In the first two years there was no evidence of any contamination. But in 2000 he picked up a small amount, less than 0.1 per cent. Again in 2001, there was a low level of GM presence.

He has not taken the products off the market yet; he is letting his customers know what the situation is and letting them decide whether to continue to purchase from him.

This contamination is particularly hard for David to deal with as over the last 10 years he has been developing an open pollinated line of maize that is specifically designed for the local climate, soil and his processing needs; maximum yield is not the priority.

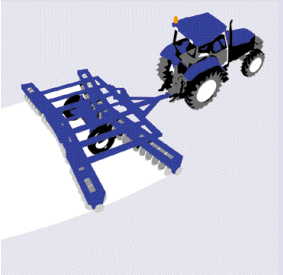
"I don't want to argue with my neighbours over the choice of what they plant, but if it impacts on my ability to farm, it becomes an issue." But his real anger is directed towards the companies developing GM technology. "They want to claim the benefits of ownership without accepting the responsibilities."

"Companies are not willing to guarantee non-GMO seed stocks to be 100 per cent non-GMO. For the future I have a lot more concern. The seed industry is pushing for higher levels of contamination to be called non-GM. Currently it is three per cent, industry are pushing for five percent. This is an admission that they cannot manage their own products."

David is currently considering legal action.[21]

7.2 **Key points**

- ★ Farmers across North America are facing severe difficulties keeping non-GM crops free from GM contamination
- ★ Wind, insects, floods and machinery are spreading seed and pollen considerable distances; industry separation distances between GM and non-GM crops are inadequate
- ★ Many organic and non-organic GM-free farmers have lost sales or received lower prices because of contamination at a potential cost of over $90 million annually
- ★ Most organic farmers in Saskatchewan have had to stop growing oilseed rape completely
- ★ To avoid contamination, organic farmers are having to incur costs by planting hedges, considering the prevailing winds, juggling their planting times and crop rotations with their neighbours, taking care with hired machinery, and testing their harvests
- ★ The specialist elevators which receive organic or IP crops from the farms are rejecting one in 20 to one in 50 deliveries because of contamination.



(from p27) certifiers inspect all the boundaries of the farm and record the existence of GM crops and assess the risks; they may take crop samples for testing. If contamination is found, the certifier may decertify the product and agree further farm management changes, or if it is a case of mismanagement or unavoidable contamination, the whole farm may be decertified. However, the levels of background contamination are such that the whole organic sector feels that it is losing the ability to control contamination.[25]

The Union of Concerned Scientists has estimated that, based on a $0.50/bushel organic price premium and an average organic maize harvest of 120 bushels, contamination could mean a potential lost income of $90 million annually for organic maize growers. This does not take into account the growth of the organic market.[26] Organic farmers are now fearing the potential introduction of GM-wheat and the loss of their ability to produce wheat, their most important crop.

The many causes of crop contamination

The rates of gene flow by pollen transfer from GM oilseed rape and maize to other crops have been investigated by the European Environment Agency. It found that GM oilseed rape is a high-risk crop for crop-to-crop gene flow and GM maize is a medium to high-risk crop.[27]

However, farmers in North America have found that there are many ways by which crop contamination can occur. As well as through airborne or insect mediated pollen, GM contamination can arrive from spillage of seed along the road. Strong winds can also shift seeds considerable distances, and, according to one US farmer, the ability of flood waters to wash seed and seedlings from one field to another is often overlooked.[28] If a non-GM crop is planted in a field that previously contained a GM variety, then contamination through volunteers is inevitable. Some farmers consider that the most frequent cause of contamination comes from equipment, such as rented combines.[29]

Strategies for minimising contamination

The impression is that GM farmers do not seem to be taking many measures to prevent contamination of neighbouring farms. There are government and industry guidelines, such as the ones for setting up insect resistance refuges which can double as separation distances. However, these do not appear to have been regularly communicated to GM farmers or enforced. They would also probably not be large enough to prevent contamination, only reduce it. It appears that the prevention of contamination has therefore fallen mainly on those who are not growing GM crops. Organic farmers in particular have had to alter their practices significantly to reduce the chances of contamination.

This involves planning, investment and extra work. Organic farmers are setting up physical barriers, such as planting hedgerows, along with trying to grow susceptible crops as far from neighbouring GM fields as possible. An awareness of the prevailing wind direction is helpful. Perhaps most important is for farmers to develop good relationships with the neighbouring farmers and learn what they are going to plant when. It is then possible to plant a little later, so that, hopefully, flowering times do not coincide. Many juggle their whole crop rotations to accommodate the timing of the nearby GM crops.[30] In addition, they have to take care to only use machinery dedicated for organic crops. Testing the harvest is the final assurance. Even with this, however, farmers need to consider carefully before committing themselves to a GM-free supply contract.[31] All of these steps will usually involve increased costs for organic farmers.

7.3 Commodity and food contamination

If you have the only bin load of non-GM in the county then it is bound to get contaminated as it travels with all the GM soya.
Gale Lush, Nebraska farmer[38]

The StarLink fiasco (see facing page) highlighted how vulnerable the whole food manufacturing and commodity system is to GM contamination. Only a tiny amount of unapproved GM maize was able to disrupt the country's entire grain supply and cause economic, health and legal problems. Contamination has also meant the loss of many buyers of North American farm produce as those wanting GM-free supplies cannot be provided for.

Although 40 per cent of the Canadian oilseed rape crop is non-GM, the impact of contamination from GM crop means that

Apache organic tortilla chips

In 1998, cross-pollination from Bt maize was suspected of contaminating an organic farm in Texas. But the contamination was not discovered until the corn had been processed and shipped to Europe as organic tortilla chips under the brand name Apache. By then the company, Terra Prima, had to recall 87,000 bags. The event cost the small company in excess of $150,000.[39]

this 40 per cent cannot be sold as GM-free.[40] Randy Jones of America Health and Nutrition Inc. explained "No one wants to buy Canadian canola as you cannot guarantee GMO-free. No one wants it because of the reputation."[41] Similarly, although 75 per cent of US maize is non-GM, the Organic Federation of Australia has stated that organic maize imported from North America can no longer be guaranteed free from GM contamination.[42] As a consequence, farmers are being prevented from accessing the premiums for non-GM crops and the market for their produce has suffered.

The lack of segregation has meant that every stage post-farm gate – transport, storage and milling – have all compounded the problems of seed-level and farm-level contamination through 'co-mingling.' If a crop that turned out to be contaminated with an unapproved GM gene entered the general system, then the crops from all the other farms which were handled together also become tainted in the market. Similarly, though there have been many farmers producing non-GM crops and many buyers for them, there was no means of maintaining the integrity of the non-GM crop to the marketplace.

Growth of segregation and testing

The pressure on the commodity markets and the repercussions of the StarLink fiasco, together with pressure from consumers and importers, have meant that systems are now being expanded to segregate GM from non-GM crops by the industry and government. The number of maize and soya elevators in the Midwestern US states that require segregation, either on delivery or on farm, had risen to over 50 per cent by autumn 2001, from under 10 per cent in autumn 1999, as revealed by a survey of 1,149 elevators by the American Corn Growers Association. In addition, almost 20 per cent are offering price premiums for non-GM grain.[43] The US government is also investing in the development and certification of GM contamination testing methods and kits.

A measure of control will have been reintroduced to the situation, but it remains to be seen whether the measures will be sufficient. Some identity preservation on the basis of quality characteristics and special varieties has been in existence in the US for years, but it is not clear whether the systems will be sufficient for non-GM

StarLink Bt maize

There has already been one major and apparently harmful case of GM food contamination, the StarLink Bt maize case. In September 2000, it was discovered that taco shells on sale contained the Cry9C protein, indicating the presence of StarLink maize. The FDA had only approved this GM maize for animal feed, not for food, due to concerns over the novel protein being a potential allergen. The contamination was not uncovered by the food industry or regulators, but the environmental organisation Friends of the Earth.

Only about one per cent of the 2000 US corn harvest, 124 million bushels of maize, was StarLink. However, this became mixed with, and contaminated, nearly half the national maize supply that year. The discovery resulted in an expensive recall and compensation operation that exposed the food industry to the practical difficulties of GM crops. Kraft Foods, the company that produced the taco shells, recalled them and all similar products. In total eventually nearly 300 food products were recalled. This caused major disruption to the domestic and export market.[32]

The US Department of Agriculture (USDA) and Aventis, the company that developed StarLink maize, agreed to a buy-back programme, in which farmers were offered 25 cents a bushel over the market price by the company, in an attempt to divert the contaminated maize into the animal feed and non-food markets.[32] The USDA also bought back seed corn from seed companies, at an estimated cost of $13 million.[33]

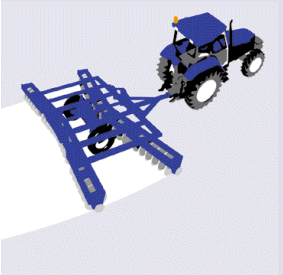
Meanwhile, over 50 Americans claimed to have suffered allergic reactions to the corn, which "varied from just abdominal pain and diarrhoea, skin rashes to some patients, a very small group, having very severe life threatening reactions" according to Dr Marc Rothenberg, allergy chief at Cincinnati Children's Hospital and a government adviser on the StarLink case.[34] After a full investigation, the independent scientific advisory committee on the case advised the government that there was a "medium probability" that the maize could cause allergic reactions.[35]

The total cost to Aventis so far is estimated to be in the region of $1 billion, and the legal consequences are still continuing.[36] Aventis has since abandoned its US production of StarLink and sold its crop science division to Bayer in October 2001.[37]

grain to have access to the GM-free markets. The key question for the future, according to the American Corn Growers Association, is whether the non-GM crops will be contaminated beyond the threshold levels used by foreign markets and governments.[44] The extra costs of segregation and testing are having to be borne by the whole industry.

7.3 **Key points**

- ★ GM contamination of the food and commodity systems has caused major domestic and international trade problems
- ★ Without segregation in the handling and distribution systems, just one per cent of unapproved GM maize contaminated nearly half the national maize supply in September 2000
- ★ The StarLink incident was a possible cause of many allergic reactions and cost Aventis an estimated $1 billion and the US government at least $13 million
- ★ The lack of segregation has meant that most Canadian rape and US maize commodity supplies cannot be sold as non-GM abroad, though only part is actually GM
- ★ As a result, market prices have fallen and few non-GM farmers can access the international premium non-GM markets
- ★ Over 50 per cent of US elevators are now requiring GM crops to be segregated from non-GM crops; the impact of this has yet to be seen.



"Genetically engineered crops represent a huge and uncontrolled experiment whose outcome is inherently unpredictable."
Dr Barry Commoner, biologist,
City University of New York, 2002[1]

8 Unpredicted effects

With the normal farming uncertainties of the weather and markets, it is important that the characteristics of any crop variety are stable and that there are not going to be completely unpredictable effects. The process of genetically engineering crop plants is described publicly by the biotechnology industry as "deliberate" and "precise", in a way that suggests it is more controlled and predictable then conventional breeding methods.[2] The official process of approving new GM varieties also assumes that any biological changes to the plants are limited. However, some farmers in America have reported experiences of unexpected and occasionally unwelcome effects.

GM feed and livestock

The main use of the GM crops which have been commercialised in North America so far is for animal feed. Maize, oilseed rape and soya are basic components of the intensive meat production industry, so the effect on livestock of these crops is very important. However no, or almost no, animal feeding trials with pigs, cattle or other livestock were carried out before the crops went into commercial production. This is surprising considering the large scale on which these novel crops were going to be used – it might have been expected that extensive, long-term trials would have been carried out. It therefore seems worth highlighting any consistent reports of unexpected effects from farmers since GM crops were introduced. The problem of the pig breeders in Iowa is the most dramatic consequence to have surfaced so far (see panel overleaf). In addition, several farmers have reported their livestock showing a marked preference for non-GM feed:

- *"If a field contained GM and non-GM maize, cattle would always eat the non-GM first".*
  Gale Lush, Nebraska[3]
- *"A neighbour had been growing Pioneer Bt maize. When the cattle were turned out onto the stalks they just wouldn't eat them".*
  Gary Smith, Terry, Montana[4]
- *"I saw an advert from a farmer who was looking for non-Bt corn, as he was getting lower milk yields from the cattle that were eating Bt corn".*
  Tom Wiley, North Dakota[5]
- *"A captive elk escaped and took up residence in our crops of organic maize and soya. It had total access to the neighbouring fields of GM crops, but never went into them".*
  Susan & Mark Fitzgerald,
  western Minnesota[6]
- *"While my cows show a preference for open-pollinated maize over the hybrid varieties, they both beat Bt-maize hands down".*
  Tim Eisenbeis, South Dakota[7]
- *"A student placed two bales of maize in a rodent infested barn. One was Roundup Ready and the other was conventional. Apparently the rodents would not touch the Roundup Ready crop".*
  Roger Lansink, Iowa[8]

An article in 1999 also catalogued several cases of problems with GM feed in the Midwest:

- Cattle refused to graze Bt-maize stubble
- Pigs went off feed when GM grains were included in the ration
- Cattle stopped eating when the farmer switched to GM silage
- Rate of weight gain in cattle dropped when switched to GM feed
- Cattle broke through a fence and walked through RR-maize to mow down a non-GM hybrid, leaving the RR-maize untouched.[9]

Iowa pig breeders

In Iowa, pig breeders believe they have encountered a serious problem with Bt maize, with 17 producers reporting a sharp decline in pig farrowing (conception) rates following the use of Bt maize in their pig feed.

Jerry Rosman experienced an 80 per cent fall in his farrowing rate after using Bt maize and four of his neighbours had the same problem. In each case the animals were exhibiting pseudo-pregnancies. Outwardly the pigs had all the signs of being pregnant but after two to four months the signs disappeared. The breeders had different management styles, breeding methods and swine genetics, but they were all feeding Bt maize.

Jerry did everything he could to find out the cause: he tested for diseases, examined his nutritional programme, verified his insemination rates and sent samples of the maize away to several laboratories. In total he spent over $6000. Laboratory tests eventually revealed that the Bt maize from all five farms had high levels of fusarium mold, suggesting the presence of mycotoxins that can cause pseudo-pregnancies. But this could not be confirmed as the cause as the one mycotoxin which is known to cause this problem was absent and other types have not yet been identified by pathologists and cannot be detected.

"We're working with a problem no one has ever heard of before" said Jerry. One of the operations has stopped feeding Bt maize, and its farrowing rates have returned to normal.

Jerry reported the problem to the state farming journal, the *Iowa Farm Bureau Spokesman*, in May 2002. Within 10 days, another 12 pig producers from various parts of Iowa contacted him with the same problem.[2]

The lack of segregation of GM from non-GM grain is likely to have masked other problems. According to Jerry Rosman, most of those who reported the pig breeding problems in Iowa were smaller producers who were growing all their own feed, generally all of the same variety. The few who were using bought-in feed and reported problems, said they had noticed fluctuating farrowing rates as they went through successive deliveries of feed.[10] Most livestock production in the US involves large, intensive 'feed lots' and bought-in feed. With only a quarter of the maize in the system being GM, the larger producers would not experience a problem consistently in the way smaller farmers would.

These negative experiences of some individual farmers do not add up to proof that there is a general problem with all GM feed. But, it is clear that several farmers (and their animals) have noticed a substantial difference between some GM and non-GM feed. Furthermore, there may be problems that have not been identified in the sector at large.

Unpredicted effects in GM plants

"In the past I would always cut the soy first as it would collapse under the weight of the beans. But now the stems are so tough they wear out the combine."

Nebraska farmer, Gale Lush, found that the RR soya he planted were tougher than the conventional variety.[3]

The commercialisation of GM crops has uncovered a few unexpected problems of plant structure and health. The unexpectedly high levels of fusarium in the Iowan Bt maize has yet to be explained. Several unexpected problems have been reported with RR soya, of which at least two are definitely related to the GM character of the plants.

University of Georgia scientists were alerted by farmers in the southern US states to unexpected soya crop losses and reports of RR soya plants splitting in hot temperatures. On investigation, the scientists found that RR soya plants are producing up to 20 per cent more lignin than other soya plants. This makes the stems more brittle, causing stunting and splitting at a far higher rate than normal soya in hot weather and leading to crop losses of up to 40 per cent. The researchers concluded that the inserted gene that gave resistance to glyphosate was affecting a major metabolic pathway in the

plant which had the side effect of sending lignin production into overdrive.[11]

As reported in chapter 4, RR soya is unexpectedly yielding 10 per cent less than equivalent non-GM varieties. It also seems to be susceptible to certain pests and diseases, and this is believed to be due to the additional genetic material suppressing the plants' stress responses. This might possibly explain why farm advisers at the University of Missouri reported inexplicably high levels of pest attack on the soya crop in 2001. "I don't know what it was this year, but we saw insects eating soybeans that we've never seen before."[12] The reason given was weather, but it could have been an abnormal response of the RR soya to the weather conditions.

Another unexpected problem that could again be due to the use of GM varieties was the poor viability of the 2001 US soya seed supplies. Seed companies reported finding it hard to meet seed germination standards. Germination targets are usually around 95 per cent, yet these were nearer 80 per cent, meaning that more seed needed to be applied per acre. The soyabeans also contained more green seed than usual, indicating that many plants had died prematurely. As with the soya stem problems, this was also linked to hot weather by the University of Missouri.[13]

Inadequate assessment prior to commercialisation

"There is a profound difference between the unintended effects from traditional breeding and genetic engineering."
Dr Louis Pribyl, scientific adviser to the FDA, 1992[14]

Government scientific advisers in the US and Canada have opposed their governments' assessment processes for the approval of GMOs, considering it unscientific. One of their particular concerns was the potential for unpredictable side effects to occur from the genetic engineering process, which would not be identified by the assessment procedures being used. In a review in February 2001, the Royal Society of Canada called the approvals regime "scientifically unjustifiable."[15] In 1992, a majority of the US FDA's scientific advisers did not support the government's proposed assessment regime for GMOs, contrary to the public statements made by the FDA. They believed that animal feeding trials would be needed to pick up undesirable side effects. The assessment procedures were adopted anyway.[16]

The procedures for the assessment of side effects from genetic engineering are based on an analysis of the levels of a limited list of chemicals in the GMO, such as key nutrients and toxins. If the levels of these are similar to those in the equivalent non-GM plants, the GMO as a whole can be deemed "substantially equivalent" to non-GM plants and few further safety trials, such as animal feeding trials, are required. This is especially so in the US. As a consequence, no or almost no animal feeding trials were carried out before GM crops were put on the market.

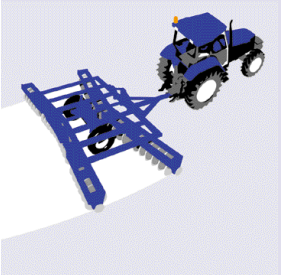
However, unlike the public descriptions of genetic engineering as "precise", the engineering of a GMO has a large random component to the process, so unpredictable side effects are expected. The process involves the foreign gene randomly inserting itself in the plant's natural genetic material, disrupting the existing genes at the point of insertion. Genetic engineers can in theory insert genes in a particular place but in practice this is not done; even if it were there is usually no suitable position which would not be disruptive. The effects of the process are that some of the characteristics and metabolic processes of the plant are likely to be randomly altered. In addition, the gene is not inserted on its own, but as part of a 'construct' with other genes, including a viral promoter gene to activate the functional gene. However, the nature of the promoter means that the inserted genes are liable to be unstable and move out again. Overall, GM plants are therefore generally highly unstable and variable in the functioning of the foreign gene from one generation to the next, as well as being expected to display unintended effects.

Behind the scenes, the biotechnology industry is well aware that the current techniques cause disruption of the plant's genetic material: "The phenomenon of rearrangements at the point of genetic insertion is widely recognised" said Marcia Vincent, technical communications manager, Monsanto, August 2001.[17] "Plant biotechnology … processes cause severe changes to cell metabolism by disrupting existing architectures or by activating defence mechanisms deigned to cope with entirely different assaults" according to two biotechnology consultants.[18] Instability is also a widely encountered problem in the industry. For example, in a survey of at least thirty companies developing GM crops, all had observed some instability of the transgene.[19]

Even when the biotechnology sector started carrying out animal feeding trials

8. **Key points**

- ★ Almost no animal feeding trials were carried out before GM crops were released for commercial growing, though their main use was for animal feed
- ★ The biotechnology companies publicly suggest that genetic engineering is a precise and controlled technique; however, several farmers have reported unexpected effects
- ★ Pig breeders in Iowa have had a major reduction in breeding levels since they started using Bt maize as feed
- ★ Many farmers have reported that cattle show a marked preference for non-GM maize if given a choice
- ★ In certain conditions RR soya has been found to be susceptible to pests and disease and stem splitting due to lignin levels being higher than in non-GM soya
- ★ Government scientific advisers in the US and Canada opposed their governments' assessment procedures for the approval of GM crops as unscientific, on the basis they would not identify undesirable side-effects of the engineering process.



after commercial growing started, they were not initially of farm animals and were often not designed to identify unpredictable effects. For example, they often involved feeding just the protein product of the new gene to the animal, and not the whole GMO. Sometimes too little of the GMO was fed in the diet; in others negative effects did occur but were ignored.[20] Over the last couple of years a few feeding trials with farm animals have been carried out, looking at aspects such as digestibility and weight gain and few significant differences have emerged so far.[21]

Another reason why side effects on the plant's structure or health are not picked up before commercialisation is because, according to one of the FDA's scientific advisers "many of these effects might not be seen by the breeder because of the more or less similar growing conditions in the limited trials that are performed."[14] Hence, it is only when the plants are exposed to the different environmental conditions of widespread commercial growing and fed to animals on farms, that changes to their normal response to environmental stresses and other side effects may emerge.

"There is no choice. It is so difficult to find guaranteed non-GM soya, and you end up with poorer varieties."
Gale Lush, farmer growing GM soya, Nebraska[1]

9 Farmer choice

With the introduction of GM crops, farmers have suffered a severe loss of choice about how they farm. Many are finding themselves forced to avoid certain crops or even to grow GM crops simply because of a lack of choice, not because of the particular GM attributes of the GM crops. Farmers who grow GM crops can then find themselves effectively 'locked-in' to growing GM crops.

Farmers are also reporting that the availability of good non-GM seed varieties is rapidly disappearing, as good varieties are increasingly only available in a GM form. Sharon Rempel, organic crop researcher from Alberta explained: "It is more and more difficult to get seed varieties, catalogues are getting thinner." And it is not just the choice in seeds that is evaporating. "In 1900 there were around 2000 seed companies in North America, now there are less than 200." Sharon is particularly concerned about control "The hand that holds the seed controls the food supply."[2]

GM contamination has exacerbated this problem. Seed and crop contamination and the lack of segregation in the marketplace has meant that many farmers do not have the option of supplying the higher value GM-free or organic markets (in much of Canada, organic rape production is no longer an option). Moreover, crop contamination has introduced the worrying uncertainty of whether a non-GM farmer might be accused by a biotechnology company of growing unlicensed GM crops.

If this happens, and it seems to have very often, the consequences are expensive and unpleasant (see chapter 12). Farmers who are already growing GM crops are susceptible to the 'lock-in' effect of GM crops – their contracts allow biotechnology company inspectors access to their farms and they may be struggling with GM herbicide resistant volunteers, making them vulnerable to claims of growing unlicensed crops. The experience of Troy Roush (p42) indicates that if a GM farmer is accused, and intimidated, he can feel that growing more, rather than less, GM crops is the best way to reduce the chances of the problem continuing.

The problem is that the leading Midwestern seed companies have been bought up by the biotechnology companies, who now only sell the most popular hybrids of the seed companies genetically engineered with HT or Bt genes.[3] DuPont and Monsanto are now the two largest seed companies in the world with combined sales in excess of $3.5 billion in 2000.[4]

Sharon Rempel

Sharon Rempel, organic crop researcher from Alberta explained "It is more and more difficult to get seed varieties, catalogues are getting thinner."[2]

Gale Lush

Gale Lush farms nearly 3,000 acres with his father and three brothers near Ragan, Nebraska. He is growing Roundup Ready soya but has been looking into identity preserved soya with a hope of gaining the reported premiums. "If I could get hold of the seed and market then I would stop growing Roundup Ready."

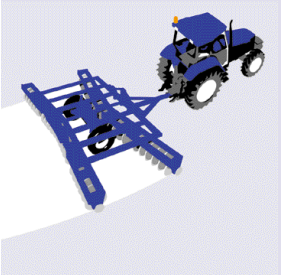
But he has not found it as easy as he thought because good non-GM varieties have become harder to obtain. "There is no choice," he explained. "It is so difficult to find guaranteed non-GM soya, and you end up with poorer varieties." This is compounded by the problems of transport and storage.[1]

Jim Stiegelmeier

Jim Stiegelmeier farms 4,000 acres of organic land near Selby, South Dakota. Soya, spring wheat, buckwheat, rye and cattle form the basis of his enterprise. Until recently his only involvement with GM crops had been lobbying against them – helping to draft resolutions for the state senate and talking about the risks. But GM crops have now forced him to change the way he farms. He has had to stop growing organic maize due to problems finding GM-free seed, and the worries of pollen drift from GM maize-growing neighbours. As for soya: "We will probably just stop growing soya if we get any contamination issues. We will just move towards more animal production."[5]

9. **Key points**

- ★ Farmers have suffered a severe loss of choice about how they farm, as a result of GM contamination and a reduction in choice of seed
- ★ Some farmers growing GM crops have felt themselves 'locked-in' to GM crops because of the difficulty obtaining non-GM seed and accessing the non-GM markets
- ★ A farmer who was accused of growing unlicensed GM crops, despite evidence to the contrary, decided to start growing GM crops just to avoid further accusations
- ★ Organic farmers are being forced to avoid certain crops because of contamination
- ★ Many seed companies have been bought up by the biotechnology companies which had led to a sharp reduction in the availability of good non-GM varieties
- ★ The continued large area of GM crops may be as much to do with the 'lock-in' effect of a lack of choice, than the attributes of GM crops.



Troy Roush

In 1999 Troy Roush and his family grew 492 acres of Roundup Ready soya under licence on their Indiana farm, alongside 1,328 acres of conventional soya beans. During harvest time Monsanto sent investigators to their land who claim to have sampled 16 fields. They alleged that 15 of these samples contained Roundup Ready soybeans.

Troy Roush was startled by this claim. To start with, the investigators were never seen by his staff on the land, despite it being the busiest time of year on the farm. He was also confused as to how they allegedly found RR soya in his fields of popcorn. This could be because some of the fields they sampled were not Roush's land. Checking back over his chemical records he could prove that only two of the fields sampled were planted with the GM seed. To be on the safe side, he asked his lawyer to get an independent review undertaken of his planting and chemical records. In a sworn deposition the consultants stated that the Roushes simply did not purchase enough Roundup seed or herbicide to account for the claims made by Monsanto.

But in May 2000, Monsanto filed a lawsuit against the family accusing them of having illegally grown Monsanto GM soya. They also sent more investigators to the farm – but this time the Roushes were ready and shadowed them, taking similar samples along with Global Positioning System readings. None of their samples showed up as positive for RR soya, yet they had been planted with seed saved from their previous year's crop. The crop that Monsanto claimed to have been a Roundup Ready crop.

In June 2001 Monsanto's lawyers sent a letter to over 900 seed suppliers, farmers and agricultural extension agents in Indiana, Michigan and Ohio stating that the company did not authorise the sale of any of their products to the Roush family.[6] In the legal battles that have continued, Monsanto have rescinded this letter. But the damage has been done. Troy said, "I wouldn't trade $100 million for the damage they've done to our family's reputation."

The family have spent $150,000 to defend themselves, but have not been able to get Monsanto to turn up in court to finish the business. In the meantime, to prevent the possibility of a similar accusation being made again, Troy has taken a radical decision: to plant every acre of his soya crop to (licensed and paid for) GM Roundup Ready beans.[7]

"Farmers are really starting to question the profit enhancing ability of products that seem to be shutting them out of markets worldwide."
Cory Ollikka, president of Canada's National Farmers Union calling for a moratorium on GM crops, December 2000[1]

10 National farm economy

GM crops were meant to have improved the competitiveness of American farming. Instead, they have turned out to be a major burden on the agricultural economy. Not only have GM crops reduced the average profitability of farming but they have made it less market-oriented: as GM crops were being introduced, so the GM market was shrinking. As a result, American farming has become more dependent on state subsidies.

10.1 International trade

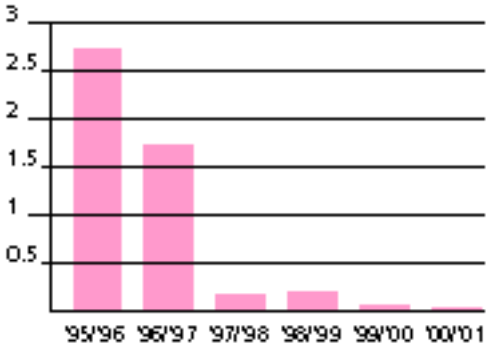
"Biotech corn has already proven to be a market destructor for US corn farmers."
Keith Dittrich, maize farmer and president of the American Corn Growers Association, January 2002.[2]

"It seems there are problems with GMO products in that they cannot be controlled in the field, they cannot be kept separated in the marketing chain and there has been inadequate independent testing of their long-term health effects. I believe the impact these products are having on our trading relationships is very troubling."
Kent Conrad, North Dakota's senator, February 2001.[3]

The most dramatic result of GM crops has been the complete collapse of major export markets. The North American experience has shown that the market for GM crops is much more restricted than it is for non-GM crops; in fact many markets are almost closed to GM produce. GM varieties only account for a part of national production but, without segregation in the industry, they have handicapped the whole trade in those sectors, GM and non-GM, at great cost to the US and Canada.

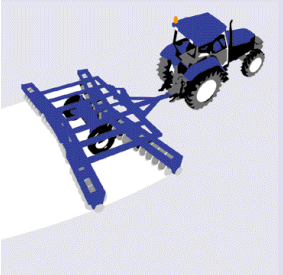
European markets in particular have rejected GM crops. Within a few years of the introduction of GM maize, US maize exports to Europe almost completely disappeared, though three-quarters of US maize was non-GM. From 1996 to 2001, according to USDA data, the value of US maize exports to the EU dropped 99.4 per cent, from $305 million (2.8 million tonnes) to $1.8 million (6,300 tonnes). In total, the US lost an estimated $2 billion in trade with Europe.[4] Canadian oilseed rape suffered a similar fate. Canada is the world's largest exporter of oilseed rape.[5] GM rape was introduced in 1996 and just two years later almost the entire $300–400 million of annual sales to Europe had vanished.[1] The trade for Canadian honey has been almost completely destroyed due to GM contamination.[6] The EU is also the largest US market for maize gluten meal (82 per cent), and US exports to Europe dropped by a fifth, from 5.5 million tonnes in 1995–96 to 4.4 million tonnes in 2000–01.[7]

US maize exports to the EU since the introduction of GM crops (in millions of tonnes)



10.1 **Key points**

- ★ GM crops have turned out to be a market failure internationally and, because of a lack of segregation, they have undermined the total trade in those commodities
- ★ Major export markets have completely collapsed, including the entire $300 million annual US maize exports to the EU and the entire $300 million annual Canadian rape exports to the EU
- ★ The US share of the world soya market has fallen from 57 per cent to 46 per cent while the share of Brazil, which prohibits GM soya, has risen from 24 per cent to 30 per cent
- ★ Almost the entire European food market has banned GM ingredients, and the US and Asian markets appear to be following suit
- ★ While only four countries are significant growers of GM crops, over 35 countries have labelling requirements or other government restrictions on GM crops
- ★ North American farm prices have fallen as a result of the market problems and many US farming organisations are now urging farmers not to plant GM seed this year.



Asian countries have also rejected North American imports. After the StarLink maize fiasco in 2000, Japan and South Korea, the biggest foreign buyers of US maize, rejected US maize over contamination concerns.[4] US maize exports to Japan dropped 52 million bushels in 2001 (1.3 million tonnes).[2] China has also become reluctant to accept GM crops. In 2000, the state of Saskatchewan exported C$123 million of oilseed rape to China, but new regulations requiring proof that GMOs are safe has put this trade in doubt. "As it stands now, we will not be allowed to ship canola into China" said Bill Mooney of Pioneer Grain.[8] China is believed to have cancelled about one million tonnes of maize this year from the US.[7]

Animal feed is the main market supporting the remaining trade in GM crops, but even this large outlet is now shrinking. In May 2001, the USDA announced: "Over the last 12 months, demand for certified biotech-free soybean meal has grown from near zero to 20–25 per cent of the EU market according to officials in the compound feed industry."[1] The US share of the world soya market has now fallen from 57 per cent to 46 per cent.[9]

The importing countries have turned elsewhere for GM-free supplies. Europe is still importing very large quantities of maize but non-GM producing countries such as Brazil and Hungary have replaced US suppliers.[7] Brazil and India are supplying non-GM soya.[1] Brazil prohibits the growing and import of GM soya, and over the last two years its share of the world soya market has risen from 24 per cent to 30 per cent.[9] It is now under intense pressure from Monsanto to allow GM soya to be grown, but the Brazilian government is resisting; its exporters have a profitable trade in non-GM soya.[1] There are now calls from the European farm sector to expand production and supply the domestic GM-free market.[10]

With the loss of markets farm commodity prices have been falling. The farming sector is starting to despair about the effect of GM crops on their trade and the farmers in non-GM countries are exploiting the situation. The main response of the US government has been to try to press other countries to accept GM crops. But farming organisations like the American Corn Growers Association (AGCA) are arguing that this is "Hardly a consumer-oriented approach" and that the best response commercially would be to try to supply market demand.[7] Twenty-six farm groups are now urging farmers to plant non-GM seeds this year to preserve their markets. Fearing Monsanto's planned introduction of GM wheat will destroy the highly valuable wheat market, the US and Canadian wheat sector is now lobbying fiercely against this.[4, 11]

International reaction

The collapse of the North American export trade has resulted from a combination of market rejection of GM food and, increasingly, of GM animal feed as well, and government rules on GM food. These factors have been compounded by the lack of segregation in the industry.

Almost the entire European food retail and manufacturing industry has adopted a ban on GM ingredients in their products (for example, Nestle, Unilever, Heinz, and the major supermarkets).[1] Publicly, the major UK retailers are stressing the non-GM nature of their own brand products, and many of them have also committed to extend their GM-free policies to animal feed for their meat and dairy products (for example Asda, the Co-op, Safeways, Sainsburys and Tesco). A number of Japanese food companies are also adopting GM-free policies.[12] China, which accounts for 12 per cent of the world soya import market has been using GM crops only for animal feed, but has started to pressure soya traders to supply non-GM soya.[1]

Underpinning these market forces are government policies on GMOs. While only four countries are heading down a GM path, there are now more than 35 countries with either laws in place, or in the pipeline, that impose special labelling or import rules on foods with GM ingredients. In total more than half the world's population is covered by restrictions on the use and sale of GM crops, and this is tightening all the time.[1]

Most of these 35 countries have adopted GM labelling rules. They include the EU, Japan (which takes 20 per cent of US food exports), China, Australia, New Zealand, Russia and the Czech Republic.[1] The EU's labelling rules cover food containing GM material, and there are proposals to extend them to also cover food derived from GMOs and GM animal feed sold to livestock producers.[13] In addition, the EU has only approved certain GM varieties for import, which means that bulk shipments containing mixtures of approved and unapproved varieties are not accepted.[12]

At an international level, the adoption of the Biosafety Protocol (signed by the US in 2000) allows importing countries to block GM products on "precautionary" grounds.[12]

Several countries such as France, Germany, Austria and Portugal have banned the import of specific GM varieties; some such as Bolivia and Croatia have imposed total bans on all GMOs.[1] Representatives of the Russian government said in 2000 they would not buy GM crops "unless there was such a desperate need to justify it."[14]

Domestic markets

The US market is now beginning to follow Europe and Asia. First, major health food retail chains such as Whole Foods and Wild Oats rejected GMOs. Now mainstream American retailer Trader Joe's has followed suit as a result of market research: "The majority of our customers would prefer to have products made without genetically engineered ingredients." Other US-based food companies, including Frito-Lay, Gerber, Heinz, Seagram and Hain, have also decided not to use GMOs in their products.[15]

A study by Rutgers University Food Policy Institute in November 2001 also revealed that the vast majority of the US population want GM food to be labelled.[1] So far the only US state to have enacted any laws on GM labelling and contamination is Maine.[16] However, the US congress is now considering GM labelling legislation.[17] The Canadian health minister also called for mandatory labelling of GM food.[18]

Interestingly, the negative market reception to GM maize, rape and soya has been replicated in several other sectors, leading to many proposed new GM crops being abandoned by the biotechnology companies. GM varieties of sugar beet, tomatoes, tobacco, flax, and rice have all been withdrawn after a negative reception from the industry and markets. GM potatoes, for example, were withdrawn from the US market after rejections by McDonald's, Burger King, McCain's and Pringles.[1]

Food aid

With mixed GM and non-GM produce piling up in warehouses, the US seems to be getting desperate to find outlets for its crops. There have been, for example, reports of a major increase in 'veggie-burger' production to use up the supplies.[19] One outlet which does not require segregation has been food aid. More than two million tonnes of food aid is sent directly from the US to developing countries each year. The World Food Programme distributes another one and a half million tonnes on behalf of the US.[20] In December 2000, the US gave $300 million to the Global Food for Education programme, a scheme to deliver 680,000 tonnes of surplus grain to countries in need. It is believed that this action was partly to support the beleaguered maize market after the StarLink crisis.[21]

This aid has not been welcomed by all the recipients. Consumer groups in Bolivia, Columbia and Equador sent samples to a laboratory which revealed levels of GMOs in soya and maize to be as high as 90 per cent. Much of this was in children's foods. Dr Elizabeth Bravo, of Acción Ecológica in Equador, said: "In Europe and the US, many baby food companies don't use engineered ingredients in their products, but the US has sent it to our children."[21] In June 2002 a Bolivian NGO announced that a sample of maize donated by the US as food aid had tested positive for StarLink. "The US considers this genetically engineered corn unfit for human consumption and has banned it for years. Yet it has been sent to Bolivia as food aid" said Gabriel Hervas, president of the Bolivian Forum on Environment and Development.[22]

10.2 **Subsidies**

"Were it not for the … income support payments … that act as a kind of limited economic damage control system … farmers would be feeling a much greater negative impact from the export sales lost as a result of GMOs."
Dan McGuire, policy chairman, American Corn Growers Association, March 2002[7]

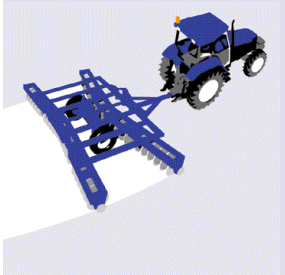
The market failure of GM crops seems to have made the agricultural sectors affected more dependent on state subsidies in the US. GM crops are certainly not the only factor, but federal farm support for these sectors has risen to record levels since their introduction and further high inputs of taxpayers' money have just been agreed.

The introduction, in 1996, of the Federal Agriculture Improvement and Reform Act (FAIR), referred to as the 'freedom to farm act', was intended to herald a major decrease in subsidies over the next seven years and move US farming towards a greater reliance on market supply and demand.[23] In 1997, the USDA predicted that total farm support would fall to $1.2 billion annually by the year 2000.[24]

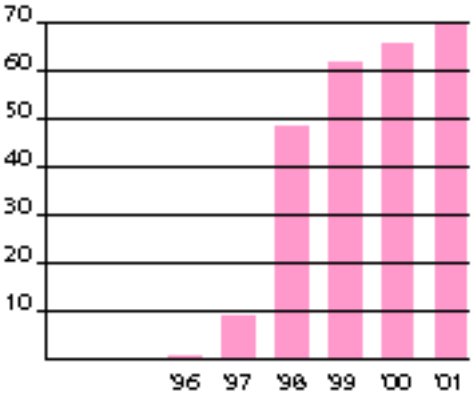
There was, instead, an "orgy of supplemental spending bills" during this

10.2 **Key points**

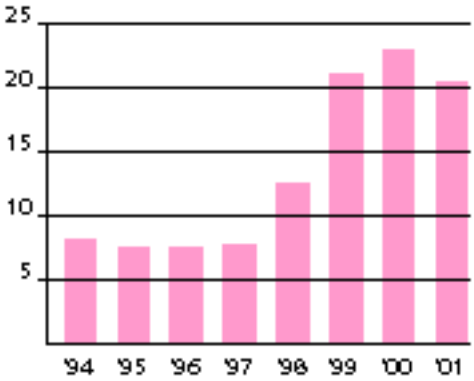
- ★ The market failure of GM crops has made US agriculture more dependent on government subsidies
- ★ US farm subsidies were meant to have decreased over the last six years but increased dramatically in line with the growth in the area of GM crops
- ★ Over this period, a series of emergency 'market loss assistance' schemes were introduced to support farmers
- ★ The soya and maize sectors received 50 per cent of the total subsidies
- ★ The loss of export markets as a result of GM crops may have required extra subsidies in the order of $10 billion over the last few years.



*Area planted to GM maize and soya in the US (in millions of acres)**



*Direct government payments to US farmers (in $billions)**



period, according to the free market think tank, the Cato Institute. Market prices for the crops the subsidy regimes support fell to near historic lows and, as a result, total direct payments to farmers rose from an average of $9 billion a year in the early 1990s to over $20 billion a year since 1998.[23]

Much of this increase came through a series of 'emergency' bills.[23] The emergencies were not primarily drought or floods but low commodity prices and disappearing export markets. Of the many different schemes by which money is passed onto the farming community, the largest is 'market loss assistance' which arrived with the wide uptake of GM crops, in October 1998. Under it, total payments rose from $3 billion in 1999 to $11.1 billion in 2000.[25]

The subsidies are far from evenly distributed across the farm sectors but the sectors with the main GM crops are all generously supported. Fifty per cent of the total subsidy money goes to the soya and maize sectors. Another 40 per cent goes to the cotton, wheat and rice sectors.[25] Soya only came into the equation in 1998, around the time GM varieties started to make an impact but it is now subsidised to 20–25 per cent of the market value of the crop.[26]

GM crops are unlikely to be the only reason why the profitability of US farming fell over the last five years. The opening of farm trade, through NAFTA (North American Free Trade Agreement) in 1994 and the Uruguay Round of the GATT (General Agreement on Tariffs and Trade) from July 1995, is likely to be a major cause. The continued rationalisation of the food and agricultural supply chain up and down stream from the farmers is likely to be another. However, GM crops appear to have been a key contributor. There is certainly a good parallel between the growth in the area planted to GM crops and the amount of money paid to farmers in subsidies (see graphs above).

Some US farm analysts have now concluded that GM crops have partly caused the rise in subsidies. According to the AGCA, as well as the higher priced seed, "the export markets that are lost as a result of GMOs cause even lower grain prices, further reducing farm incomes, while raising farm programme expenditures."[7] The AGCA calculates that the lost maize exports added about 29 per cent to the US's end of year stocks, reducing the average maize price by 13–20 per cent. After excluding subsidies, Dr Benbrook has calculated that maize production losses have exceeded $100 per acre since 1999, and that growers have only been kept afloat by the dramatic increase in subsidies.[29] He estimates that the loss of export markets has required a $3 to $5 billion increase in annual government farm subsidies.[30] This suggests that GM crops may have required total extra government subsidies of the order of $10 billion over the last few years. As GM crops are less profitable than non-GM crops, they must be more dependent than non-GM crops on these subsidies.

Despite subsidies being at record levels, the farm incomes of the majority of US farmers are still very low. Nevertheless, the subsidies have helped to mask the economic failure of GM crops from farmers.

The high levels of agricultural spending are set to continue. In May 2002, the US Senate ratified a new farm bill that will provide a record $180 billion over the next 10 years in subsidy – about 60 cents for each dollar of output, according to USDA figures. Again, this will be almost exclusively for maize, corn, soya, cotton, wheat and rice.[31]

"Farmers are being sued for having GMOs on their property that they did not buy, do not want, will not use and cannot sell."
Tom Wiley, farmer, North Dakota[1]

11 Legal issues

GM contamination has introduced North American farmers to a range of complex legal problems. A morass of litigation in the US and Canada is embracing all levels of the industry: farmers, processors, retailers, consumers, and the biotechnology companies. It includes biotechnology companies suing farmers for the effects of contamination, farmers suing the biotechnology companies for the effects of contamination, and calls from the farming industry for new GM varieties to be banned and new legislation to be introduced.

The legal issues include severe problems connected with alleged patent infringement, with Monsanto demanding money from farmers for the presence of unlicensed GM plants found on their land. It also includes lawsuits following the loss of farmers' sales and concerns over farmers' exposure to liability risks following from contamination.

The level of the problems has been such that it has led to the interest and involvement of Congress. Proposals have been tabled for comprehensive legislation to address the problems of GM crops.

11.1 Patent infringement

One of the most unpleasant outcomes of GM crop contamination is how it has made farmers vulnerable to claims that they have infringed patent rights. While disowning responsibility for the negative effects of contamination, Monsanto is pursuing its rights to its patented varieties vigorously and extensively. Farmers are told they have planted GM varieties and, backed up by the threat of legal action, many have been asked to pay large sums of money. Monsanto has even set up a special telephone number to encourage suspects to be reported to them.

At least some of the claims are contested, and, most worryingly, Percy Schmeiser's case shows that contamination of a farmers' non-GM crop constitutes a patent infringement too. Monsanto also seems to be not just asking for the fee on the proportion of the crop that is GM but for the whole crop.

The examples overleaf and that of Troy Roush (see chapter 9) are rare cases where the farmers have fought back. The most usual outcome is that farmers have agreed to pay the sums demanded. For example, in a 1998 press release, Monsanto listed five examples where they had successfully extracted money from farmers who had been "illegally pirating seed":

- David Chaney from Kentucky agreed to pay Monsanto a $35,000 royalty
- Another Kentucky farmer agreed to pay $25,000
- An Iowa farmer agreed to pay $16,000
- Two Illinois farmers paid $15,000 and $10,000.

As part of the settlements, the farmers have to sign gagging clauses and agree to Monsanto having access to their land for the following years. But as this press release shows, while the farmers are bound to silence, Monsanto has felt free to publicise the 'villains' to the rest of the farming community. The press release also states "other actions taken in 1998 include crop destruction and confiscation of seed."

It appears that Monsanto is currently taking dozens of farmers to court and threatening many more with legal action if they do not agree to pay. It has recently brought actions similar to that against Percy Schmeiser against farmers in North Dakota, South Dakota, Indiana and Louisiana.[5] It is impossible to assess the exact number of people in this situation due to the use of gagging orders with those who have settled.

Percy Schmeiser

In 1998, Percy Schmeiser, a farmer from Humbolt, Saskatchewan was served a lawsuit claiming that he had infringed a Monsanto patent by growing Roundup Ready oilseed rape without a licence. Percy is adamant that he did not grow GM rape and it could only have arrived by contamination. "In my case, I never had anything to do with Monsanto, outside of buying chemicals." If there were any GM plants among his crops, then they threatened to destroy 50 years of his work breeding conventional oilseed rape.

Percy Schmeiser decided to fight. Initially Monsanto said that they had received a 'tip-off' that he was 'brown-bagging', that is saving seed that he had no licence for. This was disputed and in the end the company admitted that there was no evidence of him cheating. But Monsanto still believed he had some of 'their' plants on his land. Indeed they claimed that over 90 per cent of his crop was GM. However, independent tests done for Percy found varying levels of RR rape from zero per cent in most samples, but one with over 60 per cent.

Percy said that he had simply planted his field with seed saved from the previous year, as he had always done. He had noticed, however, many RR rape volunteers growing near a field of a neighbour who had been growing RR rape, and thinks that is how his land became contaminated.

The matter came to court. Percy argued that he had not planted RR rape and if his crop was contaminated, he had in no way benefited, so Monsanto's claim was completely unjustified.

On 29 March 2001, Judge W Andrew MacKay's ruling sent shock waves through the farming community, and left Percy Schmeiser with a bill for some $600,000. The judgement ruled that the "source of the Roundup resistant canola … is really not significant for the issue of infringement" This means that by having Monsanto's GM seed contaminating his land, through no fault of his own, Percy Schmeiser was liable to pay the corporation for the seed's presence and indeed for his whole crop.

Schmeiser's costs were made up of about $250,000 in legal fees, $105,000 in profits that Monsanto claim Schmeiser made on the 1998 crop, $13,500 for technology fees to the company ($15 an acre), and $25,000 in punitive damages. On top of this, Schmeiser says he has spent $160,000 on legal fees and another $40,000 in time, travel and compensation for labour he had to hire when he was away from the farm. He thinks that Monsanto asked for such a large amount to intimidate others from standing up to the corporation.

"My wife always says that if she went down to Monsanto's headquarters and destroyed some of their plants by cross-pollination or contamination, she is certain she would be thrown in jail. Why does Monsanto have such a right? They admitted at my trial that they knew it would cross-pollinate or contaminate" says Percy Schmeiser.

Percy and his wife, both in their 70s, are appealing against the decision. They had been intending to retire before this all started. Now they have been forced into the limelight and asked to speak all around the world of their experiences.[2]

The Nelson Family

The Nelson family has built up a successful farming enterprise, working nearly 9,000 acres of land, in Amenia, North Dakota. When two investigators from Monsanto arrived on Rodney Nelson's doorstep in November 1999, apparently acting on a tip-off, he had no reason to worry. He had used Monsanto products but always followed the agreements.

In 1998 he had grown 62 acres of Roundup Ready soya as a trial run but was very disappointed with the variety's performance. Even if he had been interested in 'brown-bagging', this would not have been the seed to save. In 1999, he had tried a different variety of RR soya over 1,500 acres – about a third of his soya crop.[3] Aside from the $56,240 seed bill, he had paid a technology fee of $18,800 to Monsanto. But the Roundup Ready plants had again yielded poorly. Growing next to fields with conventional varieties, the modified plants yielded up to 12 bushels/acre less.[3]

The investigators set out to sample his fields. They refused to allow Rodney Nelson to accompany them. At the time he was surprised at how little time it took them to complete their work, but that was the last he expected to hear from them.

The letter that arrived in late July the following year from a New Orleans law firm came as a shock. The Nelsons found themselves accused of saving seed by Monsanto. Rodney decided to fight. The more he found out about the way Monsanto had 'investigated' them, the more determined he became to see the case through.

When he eventually managed to get Monsanto to hand over details of the allegations, he found that around 50 per cent of the samples claimed to have been collected by the 'inspectors' were not from his land. One was taken from a field of sugar beet and another was from a neighbour's field twelve miles away. When asked, Monsanto refused to say what percentage of Rodney's land had been found to have Roundup Ready soya.

Rodney also looked at what the inspectors had claimed to have done in their search – and found that it would have been physically impossible to cover all the ground claimed in the time they spent on his land.

So he was surprised that Monsanto persisted in claiming he had been pirating seed. In mid-October 2000, the company filed a lawsuit against the family, suing them for planting saved Roundup Ready soya. Rodney then spent a small fortune collecting evidence to counter their claims. As it turned out Monsanto gave in – settling the case, but still managed to get a gagging clause over the Nelsons. All Rodney was able to say was that "we are still hurting, emotionally and financially."

He would have liked to turn down the Monsanto offer and have his case vindicated in court. But with his father seriously ill, he felt he could not continue with the traumatic process.[4]

How demands for payment are made

There seems to be a well-established procedure by which seed piracy is alleged. Farmers and seed suppliers are encouraged to contact Monsanto if they have any information about suspected seed piracy. A freephone number has been specially set up in the US: 1-800-ROUNDUP.[6] When called in February 2002, Gail Outtrim of Monsanto admitted it was a 'snitch line'. It was made clear that any information given by suspicious farmers would be treated in absolute confidence. "If you see a neighbour keeping seed, you can call us, anonymously, and give us the details … We may get a call from a retailer who has noticed that a farmer is buying Roundup the year after buying Roundup Ready seeds."[7]

Hired inspectors arrive at farms to take crop samples for testing. Scott Good, a soya farmer from New Jersey described their arrival: "They showed up at my door at six o'clock in the morning. They flipped a badge out. It wasn't polite what they were saying. They acted like the FBI. I was scared."[8] It seems they usually refuse to be accompanied by the farmer.

The next stage is a letter from the company lawyers making a clear set of demands, backed up with the threat of prosecution. In November 1998, a letter was sent to an elderly farmer in Saskatchewan, who has asked to remain anonymous. The letter was from Keith MacMillan, director of legal affairs at Monsanto Canada. He stated that Monsanto had completed their investigation of the farm, with the help of Robinson Investigation Ltd, "and have very good evidence to believe that Roundup Ready Canola was planted on approximately 250 acres of land … in violation of Monsanto's proprietary rights … Prior to making any final decision as to what steps we will be taking, and in an attempt to resolve this issue in a timely and economical manner, we are prepared to refrain from commencing any legal proceedings against you subject to the following:

- You forthwith pay to Monsanto the following sum, 250A x $115/A = $28,750
- You acknowledge Monsanto has the right to take samples from all your owned or leased land and storage bins for three years from the date of this letter
- You agree not to disclose the specific terms and conditions of this settlement agreement to any third party
- You agree that Monsanto shall at its sole discretion have the right to disclose the

Carlyle Moritz

On 23 January 2002, Aaron Mitchell, the intellectual property protection manager of Monsanto, wrote to Carlyle Moritz, a farmer from Bruno, Saskatchewan. The letter stated that as a result of an investigation carried out by Robinson Investigations the previous year, "Monsanto has concluded that Roundup Ready canola was improperly planted on 140 acres." A specific location was cited.

Carlyle Moritz is one of the farmers who testified on behalf of Percy Schmeiser. He had felt it prudent to take a few precautions in the event of Monsanto taking action against him. So his attorney responded with a letter that indicated his preparedness. "In response to Mr Moritz's belief that Monsanto might attempt to set him up, and in accordance with legal advice, he took several steps to protect evidence in order that he could adequately defend himself."

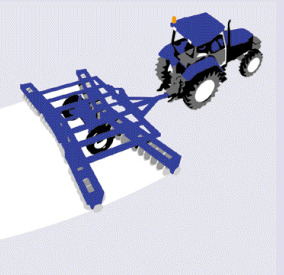
These steps included the use of independent agronomists to visit the farm and retain samples of the seeds that were sown, and getting an independent record of the type of grain sown, the acreage involved, and the GPS measurements indicating the locations.

This allowed the attorneys to point out to Monsanto that their figures were extremely inaccurate. For example, the field in question only had 84 acres planted, 34 acres seeded to non-GM oilseed rape and another 50 acres seeded to wheat in 2001. So how they determined that there were 140 acres planted to GM oilseed rape on the field is a mystery.

The attorneys conclude that "the acreages are ludicrous, the testing appears to be inaccurate … Please be assured that any further attempts to obtain payment or litigation will be met with full legal defences, including a claim for punitive damages based on the apparent disregard for any factual basis for the claim."[2]

11.1 Key points

- ★ Monsanto is accusing many farmers of growing unlicensed GM crops and demanding large sums of money or threatening legal action
- ★ Even non-GM farmers whose crops become contaminated can be successfully sued – whether they intentionally grew unlicensed seeds or had their crop contaminated is considered irrelevant under Canadian law
- ★ At least some of these claims seem to be unfounded. Some farmers have contested the claims; most have paid Monsanto up to $35,000
- ★ The accusations have far-reaching effects, with company inspectors taking crop samples, payment demands by company lawyers, gagging orders, and the farmers being required to let the company inspect their farms for the next few years
- ★ Monsanto has set-up a 'snitch-line' to encourage farmers to report on neighbours whom they suspect
- ★ To defend themselves, some farmers are now paying for independently verified crop samples and monitoring of their activities.



> facts and settlement terms associated with the investigation and this settlement agreement."[9]

As Rodney Nelson explained, it does not matter how much of the GM variety is present: "They don't test for a percentage, they just test with an 'elisa' test which gives them a 'yes' or 'no'. In other words you could have a sample of 1,000 beans that were non-GMO and have one bean in there that was GMO and Monsanto would get a positive test and you would be infringing on their patent. At least that's what they claim when they are suing you."[10]

In the above instance, the farmer fought and had the case against him dropped. Only one case has been argued through in court, Monsanto vs. Percy Schmeiser. This ended with the judgement being based not on the origin of the GM plants but simply their presence, and the judge favouring the biotechnology company. The case studies show that even if a claim is unjustified, the decision to contest the company's claim can be very expensive, painful and high risk.

A legal quagmire for farmers

If a farmer grows a GM crop without paying a technology fee to the biotechnology company that developed and patented it, they can be accused of stealing the intellectual property of that company. The farmer is infringing the company's patent. On the same grounds, farmers growing GM crops are prohibited, by the technology agreements they sign with the companies, from saving GM seed from the harvest for the following year. They have to buy new seed each year. No doubt some farmers have saved GM seed illegally; after all, saving seed has been a traditional practice in farming for a long time.

However, the farmer could easily be innocent. They could have bought some seed that someone else had saved in breach of contract, or their field might have become contaminated through airborne pollen or seeds, through hired machinery, new livestock, floodwater, or through volunteers from a previous licensed GM crop. As this report has shown, widespread GM contamination of crops is inevitable when GM crops are widely grown in a region. Farmers growing GM crops are especially vulnerable as the technology agreement allows the companies access to their land, and they may already be struggling with GM volunteers.

The Schmeiser case raises a very serious problem. If the way the seed arrives is deemed immaterial, then farmers in North America can be held accountable for the air or insect-borne transfer of patented varieties. Though they are not intentionally growing the GM crop, they can still be held responsible for GM plants appearing on their land. A non-GM farmer has few means of preventing contamination if he is in a GM growing area. The strategies that he could employ to mitigate the risk, such as planting hedges and changing his rotation, are not foolproof and would be at a cost to him. Indeed, the affected farmers feel that they are the injured party if their land has been contaminated, particularly if they are trying to supply the GM-free or organic markets or control GM volunteers.

Professor Anne Clark, from the University of Guelph, believes that the whole issue of contamination raises a legal and practical conundrum for farmers:

> "To appreciate the gravity of the choice on offer, you need to appreciate how Monsanto's hired investigators operate. They come to the door, advise you that you're suspected of brown-bagging, and offer you a letter stipulating what you must pay to avoid being formally prosecuted. Should you choose to pay the fee, you are also obliged to sign a letter which states that signing obliges you to remain silent and tell no one about what has happened, or face further prosecution.
>
> Let's say you know that you have one or more of Roundup Ready, Liberty Link, Navigator/Compas or SMART canola on your land. You know this because, like Schmeiser, the plants didn't die when you used the corresponding herbicide. So – what do you do? Do you call up the company … inform them that you have infringed upon their respective patent(s), and ask them to come out for a visit – then hope they arrive with a sprayer and not a subpoena? If the latter, no one will ever know, will they? Or do you wait for a neighbour to report you for suspected brown-bagging, using the anonymous hotline set up by Monsanto for that purpose?
>
> If the respective companies come out and actually do spray out the offending plants, do you call them back again a few weeks later, when late germinating canola has emerged in your wheat or pea crop? Will they compensate you for damage done to your crop in the process?

Arnold Taylor

Organic farmer, and president of the Saskatchewan Organic Directorate, Arnold Taylor has had to abandon growing oilseed rape on his 3,500 acre farm in Saskatchewan. This costs him C$20,000 a year as a direct loss and also restricts his crop rotation choices.[12]

The Stiegelmeiers' neighbour

Jim and Emily Stiegelmeier farm in South Dakota. They reckon that 85 per cent of the soya and at least 60 per cent of the corn in the state are now GM varieties. A neighbouring organic grower had a crop that could not be sold to the organic market as a result of contamination. He received a 'no-blame' compensation deal – there was no admission of liability.[13]

What if it was canola you were intending to plant in the contaminated field? You know that you will not be able to distinguish volunteer HT canola from whatever canola you've planted. You know that volunteer HT canola will set seed and shatter … re-contaminating the land with patent-infringing seed. Where you had one HT plant this year, you could have dozens next year. So – do you abstain from growing canola entirely?

Do you take responsibility yourself for eliminating the proprietary plants? Do you adjust your crop rotation, your herbicide expenditures – and your bottom line – to cope with contamination that you did not want and could not stop, and that will reoccur annually so long as neighbours choose to grow HT canola?"[11]

The options open to the farmer who is then faced with an unfounded or unjustified claims, are even more unpleasant. Farmers can either pay a considerable sum, or contest it. If they chose the latter, they will be locked into a complex, demanding and uncertain legal battle with a powerful company for years. From the case studies, it appears that the only way for a farmer to be able to defend himself against a claim, is to keep detailed and independently verified records of all his relevant cropping and agrochemical actions. While this effort was well justified in the case of Carlyle Moritz, it does not seem reasonable that all farmers should have to do this.

Contamination has very serious implications, for farmers growing GM crops and those trying to avoid them. The very presence of unwanted crops can result in legal action against the farmer who has suffered contamination. For farmers who fear an accusation of patent infringement, they may feel the most practical approach is simply to grow GM crops and leave no doubt, as Troy Roush did (chapter 9). Perhaps the continued large acreage of GM crops is partly to do with farmers being locked into a situation they feel they cannot escape from, rather than any real desire to be growing GM crops.

11.2 **Compensation**

As contamination spreads and the markets for guaranteed GM-free and organic products continue to grow, more and more farmers are losing business. There is a growing movement of farmers in North

Saskatchewan Organic Directorate class action

The Saskatchewan Organic Directorate (SOD) is one of Canada's leading organic sector groups. On 10 January 2002 two SOD members, Larry Hoffman and Dale Beaudoin, launched a class action against Monsanto and Aventis on behalf of all certified organic grain farmers in Saskatchewan.[14] They are seeking compensation for damages for financial loss from the destruction of the province's organic rape market that resulted from the spread of RR rape into organic varieties. They are also seeking an injunction to prevent Monsanto from introducing GM wheat into the state.[15]

Also on the table is the possibility of including the federal government in the suit because of its role in allowing the introduction of transgenic crops, said Terry Zakreski, the lawyer representing the SOD.[16]

Their claim alleges that GM oilseed rape has "spread across the prairies and contaminated conventional crops so extensively that most certified organic grain farmers no longer attempt to grow canola."[15]

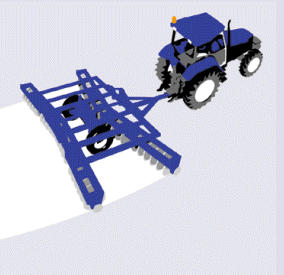
It goes on to say "when Monsanto and Aventis introduced their GE canolas they knew, or ought to have known, that the genetically engineered canola would spread and contaminate the environment. The companies had no regard for the damage these crops would cause to organic agriculture. The claim alleges that the loss of canola as an organic crop has robbed organic farmers of a high paying and growing market."[15]

The suit seeks to hold Monsanto and Aventis responsible for the economic damages of GM contamination on multiple grounds including negligence, nuisance, trespass, pollution and failure to conduct an environmental assessment.[15] Estimates for the damages run into millions of dollars.[14]

11.2 Key points

★ Farmers are turning to the courts for compensation from the biotechnology companies for the loss of sales and markets as a result of contamination

★ In Saskatchewan, a class action has been launched against Monsanto and Aventis for the loss of nearly the whole organic rape sector in the province.



America now turning to the courts to seek compensation. In the US in 2001, the National Farmers Union adopted a policy on GMOs which said that market losses must be fully reimbursed to the farmer. In Canada, the Saskatchewan Organic Directorate launched an even more ambitious project at the beginning of this year on behalf of the whole organic sector in Saskatchewan for damages for the loss of the whole organic rape market.

11.3 **Liability**

"If I contaminate my neighbor's property, I am held responsible. Farmers need legal protection to ensure that if the biotech industry contaminates their crops with GMOs, the industry is held responsible."
Tom Wiley, North Dakota Farmer[17]

Farmers considering the costs and benefits of growing GM crops have to factor in many legal liability issues. Monsanto is clear about its liability: in its 2000 technology guide, it states: "In no event shall Monsanto or any other seller be liable for any incidental, consequential, special or punitive damages … the limit of the liability of Monsanto … shall be the purchase price paid by the user."[19]

Many things can go wrong with GM crops as a result of contamination and farmers are vulnerable to being held accountable for these. The Farmers' Legal Action Group, a non-profit law advisory centre based in Minnesota, says the risks of liability for farmers growing GM crops or in an area with GM crops include:

- Tort-based liability – such as claims of damages from a neighbouring farm which has suffered economic losses from genetic drift and crop contamination. This could be based on claims of trespass, through GM pollen crossing the boundary of his farm. Alternatively, it could be based on private nuisance, through the pollen drift interfering with the use of the farm or decreasing its value
- Contract-based liability – this could result from breaching a clause in the technology agreement signed by the farmer, for example, by the farmer saving GM seed or having a contaminated crop, not planting a buffer zone, or not preventing the sold GM crop from later co-mingling with and contaminating non-GM produce. It could also result from a farmer's sales contract,

StarLink Bt maize

The legal fall out from the StarLink contamination crisis in September 2000 has affected farmers, the food industry, consumers and Aventis, the biotechnology company which developed the maize. By November 2001, nine class actions had been filed against Aventis, as individuals and companies tried to recover millions of dollars in losses and costs.

Farmers in Wisconsin who lost money due to the fall in maize prices following the crisis have filed a class action (Southview Farms vs Aventis). In another class action (Mulholland vs Aventis), farmers are suing for the domestic and foreign markets that they claim were lost because Aventis failed to prevent StarLink maize from entering the food supply. They are alleging public nuisance, consumer fraud, deceptive business practices, and negligence.[14]

Consumers have brought a class action against Aventis and several food companies, based on the allergic reactions that have been suffered. In a recent settlement the companies agreed to pay $9 million. Companies involved in the lawsuit included Kraft Foods, Azteca Foods and AstraZeneca affiliate Garst Seed.[18]

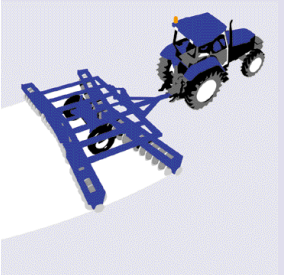
Thousands of Taco Bell restaurant franchises and other Mexican food companies have filed another class action against Aventis. They claim that the discovery of StarLink in their products resulted in the company becoming the "Poster child for concerns about GMOs."[5]

However, liability is very unclear in the StarLink case and farmers could find themselves held liable for damages. Aventis had meant to get farmers to sign a grower agreement requiring them to plant 660 foot buffer strips of non-StarLink maize around the fields and explaining that the maize was not approved for human consumption. However, many farmers claim that they were unaware of a marketing restriction and many agreements were not signed before planting. Also, StarLink maize was in many cases planted directly next to a neighbour's non-StarLink maize. Many of these then tested positive for the StarLink Cry9C protein.[5]

Just one per cent of the national corn harvest contaminated almost half the total US maize supply, which leads to some difficult legal questions. Who is liable for contaminated maize 'infecting' entire shipments of maize? Who is liable for the contamination not being picked up until the maize had been processed into a wide range of products? Who is liable for StarLink crops contaminating neighbouring crops of non-StarLink maize?

11.3 Key points

- ★ Nine class actions have been filed against Monsanto following the StarLink contamination incident
- ★ Two are by farmers for the fall in maize prices and the loss of domestic and export markets that followed
- ★ Farmers themselves may face legal challenges for problems caused by contamination
- ★ GM farmers could be held liable for contaminating the non-GM crops of their neighbours or for not preventing contamination of non-GM crops in the supply chain
- ★ Non-GM farmers could be held liable for patent infringement or breach of a GM-free sales contract
- ★ The food and farming industry are now discussing the need for an agreed framework for GM liability.



for example, for supplying GM contaminated crops on a GM-free contract

- Regulatory liability – this would apply to non-GM farmers whose crops become contaminated by GM varieties and are considered to have infringed company patent rights as a result of having unlicensed plants on their land.[5]

Frameworks for GM liability

The food and farming industry in North America is now discussing the need for a framework that establishes where liability lies for GM contamination incidents. The lack of a clear framework has meant striking inconsistencies have developed and farmers are very uncertain about their legal position. On the one hand, a contaminated crop is a liability for farmers, who can be sued by the biotechnology companies for having unlicensed GM plants on their land. On the other, farmers who have had crops contaminated are holding the biotechnology companies liable for the loss of their markets.

A framework would also mean that farmers, the industry and the government can avoid unreasonable financial costs and have means of redress. Farmers are angry that the biotechnology companies are having it both ways: claiming their economic rights to GM varieties even when they are spreading by contamination, whilst disowning liability for the negative impacts of their spread on the income of farmers.[17]

Congress is now considering a bill on liability (see chapter 11.5). Last year at least four states considered legislation on GM liability. Not surprisingly, the biotechnology industry was very active in challenging these.[20]

Strategies for managing the legal risks of contamination were also considered at a conference in Minneapolis in November 2001, which included the USDA, academia and the biotechnology industry. One recommendation was the establishment of an indemnity fund to cover the market losses caused by contamination of non-GM and organic crops, possibly through a federal crop insurance programme. Alternatively, the biotechnology companies could indemnify farmers against liability in the event of a contamination lawsuit. Another recommendation was the establishment of a standard of behaviour for GM farmers, including to identify the duty of care they owe neighbours who grow non-GM crops.[14]

11.4 **Legal bans**

"By the time it became evident to everyone that we were losing EU markets, it was basically too late…When they announced they were going to apply the GMO process to wheat, alarm bells went off."
Todd Leake, North Dakota wheat farmer and backer of state legislation prohibiting GM wheat.[21]

It is not just the organic sector but groups from the whole farming sector in North America that are trying to prevent the introduction of GM wheat. Having seen the severe economic problems with GM rape, maize and corn, the whole wheat industry in the US and Canada has been lobbying desperately for ways to prevent the same thing happening to wheat, the most valuable farm sector. They have been pursuing this in a number of different ways.

In Canada, as well as the SOD class action, more than 210 groups including the National Farmers Union and the Canadian Wheat Board demanded the halt of the approval of GM wheat last July.[23]

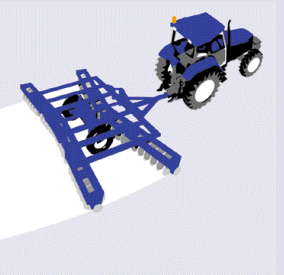
In the US, North Dakota and Montana farm representatives have sought legislation restricting GM wheat production. Terry Wanzek, chairman of North Dakota's senate agriculture committee said: "These bills are surfacing in North Dakota because of a genuine, sincere concern for the market. Our major wheat customers say they won't accept any wheat that has genetically enhanced characteristics, and we're listening to our customers."[24] In South Dakota, state senator John Koskan is working on a resolution that would prevent farmers in the state growing GM wheat.[25]

In 2001 the US National Farmers Union adopted a policy supporting a moratorium on the introduction, certification and commercialisation of genetically engineered wheat until issues of cross-pollination, liability, commodity and seed stock segregation, and market development are addressed.[26]

There are already precedents for state bans on crop varieties which threaten the trade or genetic purity of existing crops in the US. California has been requiring pre-market permits for new rice varieties and not approving those which are unapproved for export, as a way of preventing co-mingling of approved and unapproved varieties. Over 30 years ago, California outlawed some cotton varieties to maintain the genetic purity of the cotton being grown there.[27]

11.4 Key points

- ★ The North American farming community is now actively opposing the planned introduction of GM wheat
- ★ More than 200 Canadian groups, including the National Farmers Union, Wheat Board and organic farming bodies are seeking a halt to the approval of GM wheat
- ★ In the US, the NFU supports a moratorium on GM wheat and legislation banning GM wheat has been sought in some states
- ★ There are already precedents for state bans on crop varieties which threaten the trade or genetic purity of existing crops in the US.



Wheat

Across the prairies, wheat is the most important crop. Nearly 70 per cent of Canadian wheat and more than 50 per cent of US wheat is exported.[28] Currently wheat exports from Canada are over seven million tonnes a year, accounting for C$5 billion annual exports.[29] It would be devastating if the wheat industry were to suffer similar losses as the maize and oilseed rape sectors. If some of the wheat crop was GM, it would be a nightmare for the industry to manage adequate segregation after harvest.[30] For organic farmers, wheat is a major crop and essential for organic crop rotations. Losing wheat to GM contamination could destroy North American organic farming.[15]

It seems that the market will not accept contaminated or GM wheat. According to Canadian Wheat Board estimates, two-thirds of international buyers do not want to buy genetically modified wheat. A survey of the US customer base for hard spring wheat indicated that 65 per cent are opposed to GM wheat.[28] According to the American Corn Growers Association, European millers have described GM wheat as a 'market destructor' for the US.[31]

Agricultural economist Hartley Furtan has made an assessment of the likely impacts of growing RR wheat. He concluded that while there might be a small direct economic benefit, this would be swamped by the loss of premiums, costs of testing and segregation and having to rely on lower market prices.[32]

Monsanto has now pushed back its planned introduction of GM wheat from 2003 to 2004 or 2005 and has said publicly that it will only do so if it can first gain pre-acceptance from buyers.[24]

11.5 **Legislation**

"This technology is totally different from traditional breeding techniques… Current laws… were not written with this technology in mind."
Dennis Kucinich, congressman, May 2002, primary sponsor of new US legislation to regulate the GM sector.[33]

The severity of the problems with GM crops over the last few years has now convinced many US politicians that the issues require resolution at a national level. On 22 May 2002, legislation was introduced to Congress to address the economic, market and legal problems of GMOs. The five bills would

Saskatchewan Organic Directorate class action

The lawsuit by the Saskatchewan Organic Directorate (SOD) not only claims for economic damages already done, it seeks to prevent further trade losses. To prevent the loss of the organic wheat market as well, it is seeking an injunction on the release of GM wheat.

The organic community views the arrival of GM wheat with fear. Currently wheat is the most important grain grown by certified organic grain growers in Saskatchewan, and their largest export. Arnold Taylor, president of SOD said "If [GM] wheat were allowed, it would decimate the organic industry."[12]

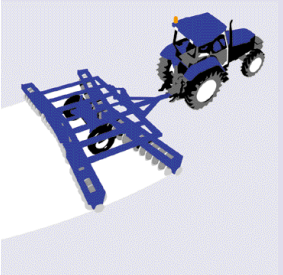
In a presentation to the Canadian House of Commons, the group said:

"This is a situation that needs immediate attention … If crops free of unintended genetic contamination cannot be grown, Canada will not be able to service the expanding markets for certified organic food. If GE wheat is allowed to be registered for continued confined trials and especially for unconfined release into the Canadian environment, there will be very negative impacts on certified organic food production."[22]

Saskatchewan farmers feel they have no choice but to take legal action. Arnold Taylor says "We've been forced to live with GE canola. We've asked for a moratorium on GE wheat, we've lobbied to change the variety registration process, and we've just hit a brick wall. We feel we have no choice left but to pursue legal action. This is a matter of survival for organic agriculture in Saskatchewan."[15]

11.5 Key points

★ In May 2002, legislation was introduced to the US Congress to address the problems of GM crops
★ One bill will introduce protection for farmers, allowing the saving of seed and compensation for crop failures
★ One bill will require all GM food to be labelled
★ One bill will make the biotechnology companies liable for all negative impacts of GMOs.



introduce legal protection for farmers, increase GM food safety, introduce mandatory labelling for all foods containing or produced with GMOs, address developing country issues, and assign liability for damages. The bills have been endorsed by the National Farmers Organisation, the Center for Food Safety, Organic Trade Association and the American Corn Growers Association. A summary of three of the bills is provided below.

HR 4812: The Genetically Engineered Crop and Animal Farmer Protection Act of 2002
A bill to provide additional protections for farmers who may be harmed economically by genetically engineered seeds, plants, or animals, to ensure fairness for farmers in their dealings with biotech companies that sell genetically engineered seeds, plants, or animals, and for other purposes.

This bill provides several farmer rights and protections to maintain the opportunity to farm:

- Farmers may save seeds and seek compensation from biotechnology companies for failed genetically engineered crops
- Biotechnology companies may not shift liability to farmers, nor require access to farmers' property, nor mandate arbitration, nor mandate court of jurisdiction, nor require damages beyond actual fees, or any other unfair condition
- Farmers must be informed of the risks of using genetically engineered crops
- Seed companies must ensure seeds labelled non-GE are accurate and provide clear instructions to reduce cross pollination, which contaminates other fields
- The Environmental Protection Agency is required to evaluate the concern of Bt resistant pests and take actions necessary to prevent resistance to Bt, an important organic pesticide.

HR 4814: The Genetically Engineered Food Right To Know Act of 2002
A bill to amend the Federal Food, Drug, and Cosmetic Act, the Federal Meat Inspection Act, and the Poultry Products Inspection Act to require that food that contains a genetically engineered material, or that is produced with a genetically engineered material, be labelled accordingly.

This bill acknowledges consumers have a right to know what genetically engineered foods they are eating:

- Requires food companies to label all foods that contain or are produced with genetically engineered material
- Requires the Food and Drug Administration to periodically test products to ensure compliance (a threshold of one per cent is established for accidental contamination)
- Voluntary, non-GE food labels are authorised
- A legal framework is established to ensure the accuracy of labelling without creating significant economic hardship on the food production system.

HR 4816: The Genetically Engineered Organism Liability Act of 2002
A bill to assign liability for injury caused by genetically engineered organisms.

- The bill places all liability for negative impacts of genetically engineered organisms upon the biotechnology companies that created the genetically engineered organism
- Farmers are granted indemnification to protect them from the liabilities of biotechnology companies
- The bill prohibits any transfer of liability away from the biotechnology companies that created the genetically engineered organism.

12 Discussion

12.1 Results

Until now most public statements about GM crops in North America have been positive. The US government and the chemical companies have stressed the widespread growing of GM crops and absence of reported problems as evidence of the desirability and safety of GM crops. As a result, some farmers' leaders in the UK have expressed concern about the UK being left behind in growing GM crops.

We have not set out to do a comprehensive survey of all experiences of North American farmers with GM crops. We wanted to see if the industry view that GM crops have been an unqualified success was true or not. We therefore sought out negative experiences and not positive ones.

The results of our research have been far more dramatic than was envisaged. We have uncovered a great variety of negative experiences for both those avoiding and those growing GM crops. These reveal fundamental problems with GM crops for the whole agriculture sector. The wider impacts of GM crops have been particularly surprising, and, until now, unpublicised.

The evidence we have uncovered shows that, however numerous the positive experiences are, the introduction of GM soya, maize and oilseed rape has been an overall failure. The failures have been on several levels, but particularly economic. We cannot identify any net benefits except the apparent convenience of HT and Bt crops. Most worrying, GM crops have been critically disruptive for the organic sector.

For farmers considering growing GM crops, the crops have not, overall, delivered on their promises of higher yields, better returns and lower agrochemical use. The only exception is Bt maize yields, though there was no net income benefit. In most cases they have performed worse than non-GM crops, including substantially lower yields for RR soya. The greater freedom to use herbicides repeatedly and the weed and volunteer problems of HT crops, must be a cause of concern for the future. The lost trade, fall in market prices, the decline in farmers' choice over their farming options and the legal liability problems have been major unexpected problems for all farmers.

Particular problems have emerged for each of the three GM crops we studied:

- *RR soya*
  At least six per cent lower yields, greater reliance on herbicides, new emerging weed problems, and plant health and structural problems in certain conditions
- *Bt maize*
  Practical constraints on growing Bt maize, lost export markets, and possible animal feed problems
- *HT rape*
  Greater herbicide use, herbicide resistant volunteers, end of most organic rape production in Saskatchewan, lost export markets.

The most serious problem that this report has uncovered is the widespread contamination which has undermined the viability of the whole farming industry. We are greatly concerned that the organic sector has been severely hit, with one Canadian province having almost lost its whole organic rape sector, many organic farmers having lost sales income and all struggling practically and economically with the effects of contamination on their businesses. In our research, we found that the organic farming community felt that they were in a critical situation. They were glad of the robust approach that Europe was taking on GMOs and hoped it would help them in North America. John Koskan, state senator for Wood, South Dakota and also an organic farmer said "The Europeans are driving this issue, and I thank them for that."[1]

Contamination has significantly increased the costs and risks of the whole industry. Non-GM farmers have found it hard, or impossible, to grow GM-free crops and access the GM-free markets for soya, maize and rape. For those that try, there is the risk of losing the sale. The threat of being accused by a biotechnology company of infringing their patent is a particularly unpleasant problem to have emerged.

The most dramatic outcome of GM crops has been the disruption to the food and farming economy. Not only have GM farmers found their crops fetching lower prices than non-GM crops, but the fall in market prices from the billions of dollars in lost trade as

a result of the lack of segregation must be a great concern. This has required roughly $10 billion in extra farm subsidies to keep farmers, particularly GM farmers, afloat over the last few years. Contamination has been a major burden on the food industry too, with the StarLink incident costing the companies involved well over a $1 billion. The only helpful aspect has been the market premiums for non-GM crops, which will be helping to offset the price fall for those growing non-GM crops. In total, with the lower profitability of GM crops, the loss of foreign trade, the lower market prices, the costs of StarLink and other incidents, the farm subsidy rise, and the lost IP and organic market opportunities, GM crops could have cost the US economy some $12 billion net from 1999 to 2001.[2]

Many of the contamination problems can be ascribed to inadequate crop separation distances and a lack of segregation in the distribution system. Though these issues are now being addressed, the costs are being borne by the whole industry, not just the GM sector, and the measures have yet to prove themselves. Overall, this report confirms the findings of the European Commission study on the theoretical risks, published earlier this year. This concluded that the introduction of GM crops would be very expensive for the European farming industry, due to the costs of managing contamination. It stated that producing GM-free crops would be extremely difficult even with significant changes in farming practice and compliance with a one per cent adventitious contamination threshold in non-GM crops could add 1–10 per cent to production costs.[3] In other words, the real and theoretical evidence is that GM crops disrupt GM-free production and greatly reduce overall agricultural competitiveness.

The ultimate confirmation of our findings must be that so many in the North American farming community are now opposing GM crops, lobbying for a moratorium on GM wheat and urging farmers to plant non-GM crops, or supporting federal labelling and liability rules to regulate the GM sector .

12.2 Why are farmers growing GM crops?

Our conclusion that GM crops have been negative for farmers and the industry in general calls into question, why so many North American farmers adopted GM crops and are still growing them. Our research has provided several possible explanations which we believe together account for the current situation:

- Initial farmer ignorance over GM crops and a very bad economic situation made farmers vulnerable to the promises being made by the biotechnology industry
- Some farmers have recounted that initially they were not told that the seed they were buying was GM – they were simply told it was a new hybrid and they did not sign any agreement prohibiting the saving of seed[4]
- The availability of many of the most popular seed varieties only in GM form after the biotechnology companies bought the leading seed companies
- Some farm businesses have experienced yield, agrochemical and overall income benefits from GM crops depending on the conditions in that area or year
- The greater convenience of HT and Bt crops, and the culture of farmers of aiming for completely weed-free fields has been assisted by HT crops
- A lack of awareness of the agronomic and market problems. Farming is an irregular business with many variable factors outside the control of the farmer, so agronomic or market problems over a few years would not necessarily be ascribed to GM crops
- The herbicide price war, apparently involving subsidised chemicals being offered to farmers, has offset the costs of higher herbicide use
- Continued heavy marketing by the biotechnology companies of the supposed benefits of GM crops. According to Shannon Story, women's president of the Canadian NFU, "the increase in acreage is the result, more than anything, of a lot of salesmanship"[5]
- A shortage of independent information – farmers need independent information to be able to judge the pros and cons of a technical development
- The 'lock-in' effect. Many factors have meant that it is not easy for GM farmers to stop growing GM crops: the shortage of good non-GM varieties, crop contamination risks, the lack of access to premium GM-free markets, and the accusations of patent infringement. The latter may have the effect of making farmers grow more GM crops, as growing less would not necessarily reduce the problems farmers face, while growing more GM crops under licence reduces the potential for dispute.

- The gagging orders used by the biotechnology companies, after patent infringement allegations, have hidden the scale of these problems from other farmers
- Farmers were told by the US government and the biotechnology companies that the international market problems were due to foreign governments putting up barriers to trade, and that the US government was addressing this. They were not told about the safety concerns and market rejection
- The ready provision of substantial extra subsidies by the US government, has masked the economic problems of GM crops.

12.3 HT crops and the biotechnology companies

It is helpful to understand the importance of HT crops to the biotechnology companies. These companies are major producers of agrochemicals. Hence the dependence of the current GM varieties on their products and the probability that HT crops will not significantly reduce the use of herbicides. Glyphosate is the world's highest selling herbicide and its sales are of fundamental importance to Monsanto. The company developed and introduced the chemical nearly 30 years ago, and has since been built on it. In 2000, Monsanto gained about half its agricultural revenue from glyphosate, some $2.8 billion.[6]

Monsanto's US patent for glyphosate, however, expired in 2000, meaning that other companies can produce the chemical, which is why herbicide prices have fallen. The technology agreements make up for the price fall. Farmers of HT crops have to pay for these and they also bind them to using the company's own brand of glyphosate. In the case of Monsanto, this is Roundup. Roundup Ready crops were the centrepiece of Monsanto's strategy to ensure its continued sales of glyphosate.[7] While publicly telling farmers that RR crops would reduce their use of herbicides, behind the scenes the company increased its production of glyphosate to coincide with the release of RR crops.[8]

To ensure an unobstructed market for their HT crops, the biotechnology industry also successfully lobbied for higher levels of glyphosate residue to be allowed on soyabeans. In 1997, the UK government raised the maximum permitted residue levels (MRL) of glyphosate on soyabeans for human consumption 200 fold.[9] The new level is 20 mg/kg.[10]

12.4 What the biotechnology companies say

The biotechnology industry has a number of arguments for their proposition that GM crops have been successful:

- They must be successful because so many farmers are growing them. This is possibly the industry's favourite argument. The list in 12.2, however, provides many less positive reasons why farmers are growing GM crops so widely in North America
- A recent industry sponsored study said that US yields have increased by 1.8 million tonnes, with Bt maize accounting for 1.5 million tonnes.[11] It is true that Bt maize has increased yields by about 2.6 per cent on the circa 25 per cent of the total maize area on which it is grown, but this was not enough to cover the higher production costs of Bt maize. Though 1.5 million tonnes is only 0.6 per cent of the total maize grown in the US each year, with the lost export markets, greater yields are only adding to maize stocks and having a negative effect on US farm prices. In contrast, the lower yields of GM soya should have reduced the total soya production
- The study also said that GM crops had reduced farmer production costs by $1.2 billion a year, with $1 billion accounted for by HT soya. It is hard to see how this can be right. The technology fee is a significant extra cost of GM crops and while herbicide costs have indeed fallen for farmers using HT crops, this is mostly due to the large fall in herbicide prices, rather than the attributes of HT crops which are encouraging farmers to apply more herbicide. In addition, the industry figure of a $1.2 billion saving has to be balanced against the costs to individual farmers of the lower market prices and the contamination problems
- HT crops lead to lower herbicide use. There is much evidence referred to by the biotechnology industry showing that HT crops lower herbicide use. But according to the independent researcher Dr Benbrook, many of the claims that RR soya reduces herbicide use can only be

made with "a little misinformation and a major dose of missing information."[12]

- HT crops help the environment because they facilitate no-till. No-till has certainly been one of the main ways in which farmers have reduced soil erosion in the American Midwest. No-till is likely to be a popular practice with the biotechnology companies because it is dependent on herbicide use, a feature that is fine for them but means this system is not necessarily better environmentally.

12.5 The political situation in the UK

UK agriculture is still suffering economically from a number of high profile, costly health scares and a poor trading climate. It is hard to see that it could withstand a new economic burden, and the government would not be ready to increase farm subsidies in the way that the US government has following the introduction of GM crops.

The farm health problems of BSE/CJD, E.coli and salmonella, foot and mouth disease and concerns over GMOs, have led to a public crisis of confidence over the government's ability to handle risks in agriculture and to reflect consumer interests. This was the main reason for the establishment of the Food Standards Agency (FSA) in April 2000. However, the FSA has yet to take a precautionary, consumer-oriented position on GMOs, in the way it has for BSE.

There is clear public opposition to GM food and crops, as shown by numerous surveys and strong local opposition to GM crop sites. Current GMOs offer no benefit to consumers, only a set of poorly researched risks. The public have clearly expressed their wish to retain the choice of GM-free food and for labelling to enable this choice. A recent survey by the Consumers Association found 94 per cent of consumers want GM food to be labelled.[13] With the GM-free policies of all the major food retailers there is no market for GM food in the UK and the market for GM feed is disappearing. As long as a large proportion of consumers continue to demand GM-free food, these companies are unlikely to change their policies. In other words, unlike North American farmers, UK farmers would not even have a domestic market were they to grow GM crops.

The public instead support a return to less intensive food production methods, based on more natural processes. Research commissioned by the FSA of consumer views, including those of low-income consumers, concluded that the preference of consumers is for "farming to become less intensive."[14] In particular, there is a strong demand for organic food and an expansion of organic farming. Three-quarters of households bought some organic food in 2001,[15] and surveys show that 65 per cent of people think that at least 30 per cent of farmland should be organic (MORI, February 2001) and 85 per cent want the government to do more to encourage organic food (NOP, March 2001). The organic sector also offers important economic opportunities for UK farmers. It is a high value and growing market, worth £800 million in April 2001, with 70 per cent being supplied by imports.

The government has already invested in the development of organic farming in the UK, through research and support for farmer conversion. In the year to 2001, it spent over £20 million on the organic sector, and over a seven year period from 2001, it has budgeted to spend £140 million on farmer conversion in England alone.

A primary policy objective of the Department for Environment, Food and Rural Affairs is "to promote a sustainable, competitive and safe food supply chain which meets consumers' requirements."[16] The findings of this report show that GM crops would obstruct the government in meeting its objectives for food and farming.

Finally, the government is publicly committed to ensuring that the expansion of organic farming is not undermined by GM crops. One of the government's 'public service agreements', is an expansion of organic farming. In 1998 the UK minister for food safety, Jeff Rooker, told the House of Commons that the government would "ensure that the expansion of organic farming is not compromised by the introduction of genetically modified crops … Given the extremely tight public expenditure restrictions to which we are subject as part of our contract with the electorate, it would be stupid for the government to push more money into converting to organic farming while allowing the farmers who take that brave step to be damaged by other actions." He went on to say, "I genuinely mean that – those are not words to be put in *Hansard* and forgotten about; I shall follow through."

13 Conclusions

The findings of our report are that GM soya, maize and oilseed rape have overall been very negative for North American farmers and the farming industry in general. While we have not researched the positive experiences, the independent evidence and feedback from the industry is that overall these GM crops have mostly failed to realise their claimed agronomic benefits and have overall been a disaster economically for the whole farming industry and especially for the organic sector.

The large number of problems and negative experiences include the loss of most of the organic oilseed rape sector in Canada; lost income for organic and other GM-free producers; problems of yield; greater reliance on herbicide use; reduced farm incomes, herbicide resistant volunteers; widespread contamination of seed resources, crops, the food system and bulk commodities; a decline in farmer choice over their business options; lost export trade; farm price falls; an increased need for government subsidies; and legal liability problems for farmers over company patent rights on GM plants. The main benefit for farmers seems to have been the convenience of HT crops, but this has not translated into income benefits. The other positive aspect has been the increase in Bt maize yields, but this too has not produced net income benefits.

The findings show that GM crops would obstruct the UK government from meeting its public commitments and policy objectives: to ensure that the expansion of organic farming is not undermined by the introduction of GM crops and that farming should be competitive and meet consumer requirements.

The Soil Association hopes this report will be the start of a more balanced and realistic debate on the likely impacts of GM crops on farming in the UK, and help ensure an informed decision on whether to allow commercial growing of GM crops or remain GM-free. We hope that the UK farming community and government will base their decisions on the independent and industry evidence of the impacts of GM crops on farmers in North America.

Appendices

A1 Glossary

Brown-bagging
The saving of some seed from a harvest by a farmer to use for planting in the following year, in contravention of company licence agreements.

Bt
The soil bacteria, *Bacillus thuringiensis*, which produces an insecticidal toxin. Bt is used by organic farmers as a form of biological pest control. Some crops have been genetically engineered to continuously produce the Bt toxin – Bt crops.

Bushel
a measure of volume, equivalent to 64 US pints (35.2 litres). One-hundred bushels of maize is approximately 2.5 metric tonnes.

Canola
The American term for oilseed rape.

Class action
A legal action brought by a few people, acting for a larger group.

Corn
The American term for maize.

Elevator
The first destination for harvested grain crops in North America, where they are cleaned and sorted before being taken to processing plants.

FDA
Food and Drug Administration, a US government agency.

Gene flow
The introduction of genes, and hence the associated characteristics, into a population usually as a consequence of cross fertilisation.

Gene stacking
The occurrence of several genetically engineered traits in a single plant. This can either be intentional or the result of gene flow.

Genetic engineering
A process by which the genetic make up, and thus the characteristics, of an organism is altered artificially, usually by inserting specific sequences of DNA into the organisms' own DNA. It is completely different to natural reproductive processes. Often DNA is used from a different species with which normal breeding would be impossible.

Glyphosate
A broad spectrum herbicide, developed by Monsanto. Now the world's widest selling herbicide, sold in many formulations, including Roundup.

Glufosinate
A broad spectrum herbicide, marketed by Aventis under the name Liberty.

GM
Genetically modified. GM, genetically engineered, or transgenic are all terms that describe an organism or product of an organism that has undergone genetic engineering. GMO = genetically modified organism.

GM-free/non-GM
In the report, GM-free refers to seeds or crops which are not of GM varieties and are free from any adventitious GM contamination. Non-GM refers to seeds or crops that are meant to be only of varieties that have not been genetically modified, but which have or may have a low level of GMOs present as contamination, because measures have not been taken to avoid the risks of contamination where such risks exist.

Herbicide/pesticide/agrochemical
Throughout the report herbicide refers to chemicals which are used to kill weeds; pesticide refers to chemicals such as insecticides used to kill animal pests; and agrochemicals for the whole range of chemicals used in agriculture. However, in some quotes 'pesticide' is used in its American meaning to cover herbicides as well.

HT
Herbicide tolerant. HT crops are resistant to the effects of a particular herbicide, usually as a result of genetic engineering, for example, Roundup Ready soya.

IP
Identity Preserved. A process of managing seed, crops, food or other products to guarantee the integrity of the final product with respect to its original ingredients, for example to guarantee that the product is not contaminated with GMOs. It may involve GM testing, segregated processing facilities, the cleaning of equipment between GM and non-GM lots, record keeping, and independent auditing. IP systems are used by manufacturers and retailers to sell produce as GM-free.

Isolation distances/separation distances/buffer strips
Distances used to separate GM from non-GM crops to reduce the chances of GM contamination by pollen transfer.

Multiple resistance
The development of resistance to several herbicides in one plant, such as would result from gene stacking of separate herbicide tolerant traits.

No/low-till farming & minimum till
The practice of sowing land after no or only very shallow soil cultivation, instead of the traditional practice of ploughing land. It involves clearing the land chemically of weeds instead and drilling seeds directly into the soil. It is used commonly to reduce soil erosion in the American Midwest, though it involves a greater use of herbicides than systems based on mechanical ploughing and cultivation.

Pollen drift/transfer
The movement of pollen by air or insects often far from the original plant, which can transfer genetically engineered traits to compatible non-GM crops.

RR
Roundup Ready. RR crops have been genetically engineered to be tolerant to Roundup, a brand name for glyphosate herbicide.

Saving seed
The saving by a farmer of a proportion of the seed from his harvest for sowing another crop in subsequent seasons. This is a traditional practice carried out by approximately 20–25 per cent of farmers, mainly small farmers, in the US and UK.

Substantially equivalent
A term used to describe GM crops that have similar levels of certain chemicals, usually nutrients and toxins, to their non-GM counterparts and are as a consequence considered otherwise similar to the non-GM crops by regulatory authorities. This approach forms the basis for the approval of GMOs and has been heavily criticised for its use as a replacement to full safety testing.

Superweeds
Wild or domestic plants that have developed immunity to herbicides, usually through gene transfer from GM herbicide tolerant crops, meaning that they cannot be chemically controlled as easily as other weeds.

Technology fee
Additional charges that GM seed companies add to the price of buying GM seeds.

Technology use/grower agreement
Contracts between the biotechnology company or GM seed distributor and the farmer. They allow the farmer to use the GM seeds in exchange for complying with all of the company's management requirements, such as separation distances. They may allow the company access to the farmers' fields to inspect crops to look for any GM crops that are not covered by the agreement.

Tort
Part of the civil law (as opposed to criminal) where private citizens are able to sue each other, corporate bodies or the state.

Transgenic
Genetically modified. See 'GM'. Transgenes refers to the foreign genes which have been genetically engineered into a GM organism. They may be found in non-GM plants following cross-pollination with a GM variety.

USDA
United States Department of Agriculture, the US ministry for agriculture.

Volunteers
Unwanted crop plants, that were either planted in a previous season and failed to germinate then or that grow from spilt seed from a previous harvest.

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Soil Association

The Soil Association is a membership charity which was founded in 1946 by a group of farmers, scientists and nutritionists who were concerned about the way food was produced. It is at the centre of the campaign for safe, healthy food, an unpolluted countryside and a sustainable farming policy in Britain and worldwide.

The organisation has now grown in scope and complexity but the core principle is essentially simple; there are direct links between the health of the soil, plants, animals and humans, and organic agriculture is a sustainable system of food production which is based on these interconnections: healthy soil, healthy food, healthy people.

To achieve this end, the Soil Association is working in many different areas:

- Policy. Working to achieve change in food and farming systems through lobbying and policy work.
- Campaigns. Joining forces with members, supporters and other like minded groups to campaign for the elimination of GMOs from the food chain; promoting the responsible use of antibiotics in farming; working in partnership with conservation agencies to protect wildlife and biodiversity.
- Setting organic standards to ensure the integrity of organic food and other products. Soil Association Certification Ltd, a subsidiary company, runs the certification scheme used by 80 per cent of UK licensed operators and awards the Soil Association symbol.
- Providing professional, technical support to farmers and growers with the aim of increasing the amount of land farmed organically and providing more jobs in the countryside.
- Promoting organic food so that people everywhere will have the opportunity to buy and eat organic food, be it from a local market, a box scheme, a corner shop or a supermarket.

The Soil Association provides modern, practical solutions to the challenges facing society today.

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