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30 years of genetically engineered plants - 20 years of commercial cultivation in the United States: a critical assessment

Dr. Christoph Then for Testbiotech,
January 2013

The Greens | EFA in the European Parliament

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Content

Summary

first genetically engineered plants were created 30 years ago. Commercial growing in the USA began almost 20 years ago. Compared to the EU, developments in the USA were driven to a much greater extent by the business interests of companies such as Monsanto. Nevertheless, the EU has seen an opening up of its markets for the import of products derived from genetically engineered plants. In 2013, further decisions can be expected on new authorisations for cultivation in the EU.

In the light of this development, we have critically assessed past experience in the USA and made recommendations for the future handling of this technology in the EU. The principal findings are:

- **Consequences for farmers**
  Initially, although US farmers had a number of advantages from cultivating herbicide-resistant crops (savings in working time, spraying lesser amounts of herbicide to kill weeds) this is now mostly reversed. The weeds have adapted to the cultivation of the genetically engineered plants so that farmers are experiencing a substantial increase in both working hours and the amounts of herbicide they require.
  Even the pest insects targeted by the cultivation of insecticide-producing plants have partially adapted. Secondary pests have now spread throughout maize cultivations and we have a scenario where plants have been genetically engineered to produce up to six different toxins. It is doubtful whether this kind of "arms enhancement in the fields" will bring long-term success in the fields.
  Agricultural technologies are drawing farmers into a production systemisation that will force agriculture towards more industrialisation and massively increase costs for seeds, without there being a substantial increase in yields or significant savings in the amounts of spray required.
- **Consequences for seed markets.**
  Agrochemical companies such as Monsanto are not traditional breeders. When genetic engineering was introduced and it became possible to file far-reaching patents, these kinds of companies saw an opportunity to access the market and implement new strategies for maximum profit.
  In the meantime, companies such as Monsanto, Dupont and Syngenta, dominate the international seed market even in conventional breeding sectors. Prices for seeds are increasing and the number of farmers using seeds from their own harvest has fallen steeply. Amongst other things, companies are resorting to sending out detectives to investigate possible patent infringements and, in the USA, the available range of conventional types of plant breeds such as maize is already strongly reduced.
  In future, developments in the USA point to the continuing strong influence of agro-chemical companies, and the further neglect of alternative growing methods, which would lead to an effective reduction in the use of herbicide sprays.
- **Effects on non-genetically engineered products**
  Contamination with non-authorised genetically engineered plants has already caused millions of dollars worth of damage in the USA.
  Furthermore, contamination with plants authorised for cultivation is not systematically registered and, as yet, there are no co-existence or liability regulations in place, so that in some regions it is no longer possible to have a non-genetically engineered and/or ecological form of agriculture. The actual economic damage to non-genetically engineered products cannot be quantified.

› **Consequences for consumers**

US industry has, so far, thwarted any attempt to introduce the labelling of genetically engineered products in food. The consequence is that consumers do not have any real choice and the markets are not differentiated as they are in the EU.

Accordingly, this has affected agricultural practice. Consumers do not have sufficient influence through their purchasing behaviour to counteract undesirable developments in agriculture.

At the same time, consumers in the USA are exposed to a whole range of insufficiently investigated risks regarding unintended substances from plant metabolism, from residues from complementary herbicides and from the properties of additional proteins produced in the plants. As yet, there is no way of monitoring the actual effects that consumption of these products might have.

› **Effects on the environment**

The cultivation of genetically engineered plants is closely associated with substantial increases in the amounts of herbicide required. Contamination with certain insecticides has also increased significantly.

In particular, it has been proven that the cultivation of herbicide-resistant plants leads to a reduction in biodiversity as well as having an effect on soil and plant health. Many scientists are warning that there is a danger to the health of people living in places where crops are regularly sprayed with large amounts s of glyphosate. Furthermore, the effects of insecticide-producing plants on so-called non-target organisms have still not been properly investigated.

Genetically engineered rapeseed has already managed to escape from the fields into the environment from where it cannot be withdrawn, and from where it evades any adequate control of the effect it has on the environment. The long-term consequences of such genetically engineered plants escaping into the wild cannot be reliably assessed.

› **Consequences for the EU**

As yet, genetically engineered maize is only grown in very few regions of the EU. However, in 2013, a whole series of decisions can be expected to be made including a decision on the cultivation of herbicide resistant soybean. Considering the outcome that cultivation of such plants has had in the USA, these pending decisions should be considered as decisive for the future development of agriculture in the EU.

Importing millions of tons of feed means that a whole range of products from US agriculture are finding their way into food production in the EU. With these products, residues from herbicides and/or insecticides, which were either completely absent or only present in smaller amounts, will be continuously absorbed into animal feed. The consequences for the long-term health of livestock, and products derived thereof has not yet been adequately investigated.

The consequences of having patents on seeds have long since reached the EU. Although this started with patents on genetically engineered plants, there are now patents on conventional breeds and many plant-breeding companies have been bought up. Monsanto, for example, already has a substantial share of trade with vegetable seeds in the EU, even though no genetically engineered vegetables are produced here.

Recommendations

1. Refrain from commercial cultivation of herbicide resistant or insecticide-producing plants in the EU.
2. The question of whether plants can be withdrawn again once released should be crucial when considering applications for commercial cultivation.
3. Implement preventative measures to protect seeds from contamination to secure long-term non-genetically engineered production.
4. Substantially raise the standard of requirements for risk assessment.
5. Intensify monitoring of long-term effects on health and the environment.
6. Press ahead with the labelling of products derived from animals fed with genetically engineered plants to enable a stronger differentiation of the markets.
7. Set effective limits to the patenting of seeds.
8. Encourage more research into alternatives in conventional breeding.

Zusammenfassung auf Deutsch

Vor 30 Jahren wurden die ersten gentechnisch veränderten Pflanzen hergestellt, seit fast 20 Jahren werden diese in den USA kommerziell angebaut. Im Vergleich zur EU wird die Entwicklung in den USA wesentlich stärker von Firmen wie Monsanto und deren wirtschaftlichen Interessen geprägt. Allerdings hat auch in der EU längst eine Marktöffnung für den Import der Produkte gentechnisch veränderter Pflanzen stattgefunden. Jetzt stehen 2013 weitere Entscheidungen über neue Zulassungen für den Anbau an.

Vor diesem Hintergrund werden die bisherigen Erfahrungen in den USA kritisch untersucht sowie Empfehlungen für den Umgang mit dieser Technologie in der EU vorgestellt. Die wesentlichsten Befunde sind:

- **Auswirkungen für Landwirte**
  Die US Landwirte hatten zunächst Vorteile beim Anbau herbizidresistenter Pflanzen. Diese anfänglichen Vorteile (Arbeitszeitersparnis, geringere Aufwendungen an Spritzmitteln bei der Unkrautbekämpfung) haben sich jedoch ins Gegenteil verkehrt: Da die Unkräuter sich an den Anbau der gentechnisch veränderten Pflanzen angepasst haben, steigen sowohl die Mengen an Spritzmitteln als auch der Arbeitszeitaufwand deutlich.
  Auch an den Anbau insektengiftproduzierender Pflanzen haben sich die Schädlinge zum Teil angepasst. Nachdem sich sekundäre Schädlinge im Maisanbau ausgebreitet haben, werden die Pflanzen jetzt mit bis zu sechs Giftstoffen gleichzeitig ausgestattet. Ob diese Art von „Aufrüstung" auf dem Acker langfristig Erfolg haben kann, ist zweifelhaft.
  Insgesamt geraten die Landwirte durch die Agro-Gentechnik in eine Produktionslogik, welche die Industrialisierung der Landwirtschaft immer weiter vorantreibt und die Kosten für das Saatgut vervielfacht, ohne dass es zu bedeutsamen Zuwächsen bei der Ernte oder signifikanten Einsparungen bei den Spritzmitteln kommen würde.
- **Auswirkungen für Saatgutmärkte**
  Agrochemie-Konzerne wie Monsanto sind keine traditionellen Züchter. Erst die Einführung der Gentechnik mit der Möglichkeit, weitreichende Patente anzumelden und neue Strategien zur Gewinnmaximierung umzusetzen, lieferte diesen Konzernen den Anreiz, in den Markt einzusteigen. Inzwischen dominieren Konzerne wie Monsanto, Dupont, Syngenta, Dow AgroSciences und Bayer den internationalen Saatgutmarkt sogar im Bereich der konventionellen Züchtung. Die Preise für das Saatgut steigen, die Anzahl der Landwirte, welche die eigene Ernte zur Wiederaussaat verwenden, ist stark zurückgegangen. Mögliche Patentverstöße der Landwirte werden unter anderem mit hilfe von Detektiven verfolgt. In den USA ist das Angebot an konventionellen Sorten bei Pflanzenarten wie Mais bereits stark eingeschränkt.
  Auch in Zukunft steht zu erwarten, dass die Entwicklung in den USA von der Logik der Agrochemie-Konzerne geprägt wird und alternative Anbaumethoden, durch die zum Beispiel der Einsatz von Spritzmitteln effektiv reduziert werden könnte, weiterhin vernachlässigt werden.
- **Auswirkungen auf gentechnikfreie Produzenten**
  Durch Kontaminationen mit nicht zugelassenen gentechnisch veränderten Pflanzen ist in den USA bereits ein Schaden vom mehreren Milliarden Dollar entstanden.
  Da Kontaminationen mit für den Anbau zugelassenen Pflanzen nicht systematisch erfasst werden und hier bisher keine Koexistenz oder Haftungsregeln bestehen, ist eine gentechnikfreie und/oder

ökologische Landwirtschaft in manchen Regionen nicht mehr möglich. Die tatsächlichen wirtschaftlichen Schäden, die hier für die gentechnikfreien Produzenten entstanden sind, lassen sich nicht beziffern.

- **Auswirkungen auf die Verbraucher**
  Effektive Vorschriften zur Kennzeichnung gentechnisch veränderter Produkte in Lebensmitteln wurden von der US-Industrie bisher verhindert. In der Folge haben die VerbraucherInnen keine echte Auswahl, die Märkte haben sich nicht wie in der EU differenziert.
  Dies hat umgekehrt Auswirkungen auf die landwirtschaftliche Praxis: Die VerbraucherInnen können durch ihr Kaufverhalten keine wirtschaftlich nachhaltigen Impulse setzen, um den Fehlentwicklungen in der Landwirtschaft gegenzusteuern.
  Dabei werden die VerbraucherInnen in den USA einer ganzen Reihe von nicht ausreichend untersuchten Risiken ausgesetzt, die in Zusammenhang stehen mit unbeabsichtigten Stoffwechselprodukten in den Pflanzen, den Rückständen der Komplementär-Herbizide und den Eigenschaften der zusätzlich in den Pflanzen gebildeten Eiweißstoffe. Bisher gibt es keinerlei Möglichkeiten, die tatsächlichen Auswirkungen des Verzehrs dieser Produkte zu beobachten.
- **Auswirkungen auf die Umwelt**
  Der Anbau gentechnisch veränderter Pflanzen ist mit einer erheblichen Steigerung der Ausbringung von Herbiziden verbunden. Auch der Eintrag von bestimmten Insektengiften hat deutlich zugenommen.
  Insbesondere für den Anbau herbizidresistenter Pflanzen sind ein Rückgang der Biodiversität sowie Auswirkungen auf Böden und die Pflanzengesundheit belegt. Eine Gefährdung der Gesundheit für Menschen in Anbaugebieten, in denen regelmäßig große Mengen von Glyphosat ausgebracht werden, halten verschiedene Wissenschaftler für wahrscheinlich. Nach wie vor nicht ausreichend untersucht sind die Auswirkungen des Anbaus von insektengiftproduzierenden Pflanzen auf sogenannte Nichtzielorganismen.
  Beim Anbau von gentechnisch verändertem Raps haben die Pflanzen den Sprung vom Acker in die Umwelt geschafft und entziehen sich damit der Rückholbarkeit und einer effektiven Kontrolle ihrer Auswirkungen auf die Umwelt. Die langfristigen Folgen dieser Auswilderung gentechnisch veränderter Pflanzen können nicht verlässlich abgeschätzt werden.
- **Auswirkungen für die EU**
  Bisher gibt es in der EU nur wenige Regionen, in denen gentechnisch veränderter Mais angebaut wird. Allerdings stehen eine Reihe weiterer Zulassungsentscheidungen an, darunter auch ein Antrag auf den Anbau herbizidresistenter Soja. Angesichts der Folgen des Anbaus dieser Pflanzen in den USA können diese anstehenden Entscheidungen als richtungweisend für die weitere Entwicklung der Landwirtschaft in der EU angesehen werden.
  Durch Importe von Millionen Tonnen von Futtermitteln gelangt auch eine große Palette von Produkten aus der US-Landwirtschaft in die Nahrungsmittelproduktion der EU. Mit diesen Produkten geraten auch Rückstände von Pflanzenschutzmitteln und/oder Insektengiften kontinuierlich ins Tierfutter, die bisher in Lebens- und Futtermitteln nicht oder nur in geringeren Mengen vorhanden waren. Welche Auswirkungen das langfristig auf die Gesundheit der Nutztiere und auf

die von ihnen gewonnenen Produkte hat, ist nicht ausreichend untersucht.
Die Auswirkungen der Patentierung von Saatgut haben die EU längst erreicht. Ausgehend von Patenten auf gentechnisch veränderte Pflanzen werden inzwischen auch konventionelle Züchtungen patentiert und Pflanzenzuchtfirmen aufgekauft. So hält beispielsweise Monsanto bereits erhebliche Anteile am Handel mit Gemüsesaatgut in der EU, obwohl hier kein gentechnisch verändertes Gemüse produziert wird.

Empfehlungen

1. Es wird empfohlen, in der EU auf den kommerziellen Anbau von Pflanzen zu verzichten, die herbizidresistent sind oder Insektengifte produzieren.
2. Bei der Prüfung von Anträgen auf kommerziellen Anbau sollte insbesondere auf die Rückholbarkeit der Pflanzen geachtet werden.
3. Um langfristig eine gentechnikfreie Produktion zu ermöglichen, muss der Kontamination von Saatgut vorgebeugt werden.
4. Die Anforderungen an die Risikoabschätzung sollten deutlich erhöht werden.
5. Das Monitoring der langfristigen Auswirkungen für Umwelt und Gesundheit müsste intensiviert werden.
6. Die Kennzeichung der Produkte von Tieren, die mit gentechnisch veränderten Pflanzen gefüttert werden, sollte vorangetrieben werden, um eine stärkere Differenzierung der Märkte zu ermöglichen.
7. Der Patentierung von Saatgut sollten wirksame Grenzen gesetzt werden.
8. In der Forschung sollten verstärkt Alternativen in der konventionellen Züchtung gefördert werden.

1. Introduction

The United States has been one of the main pioneers in the development and marketing of genetically engineered organisms. In cooperation with Monsanto, researchers from the US and Europe developed the first genetically engineered plants in 1983. In 1994, the first genetically engineered crops appeared on the US market, and in 1996, the first genetically engineered crops to be imported to Europe came from the US. As Table 1 shows, the United States has been a global leader in the release, marketing and patenting of genetically engineered organisms ever since.

Table 1: Some key dates in the history of genetic engineering in the United States

1980	Patent granted for a microorganism in the United States (bacteria designed to break down oil slicks, 'Chakrabarty' case).
1983	First genetically engineered plant developed by researchers in the US and Europe in cooperation with Monsanto.
1985	First release of genetically engineered bacteria (ice-minus bacteria) in the United States.
1986	Release of genetically engineered tobacco in the United States and France.
1988	First patent granted for a genetically engineered mammal in the United States ('OncoMouse').
1994	The first genetically engineered foodstuff placed on the US market: the Flavr-Savr tomato, designed to be harvested when ripe and keep for longer. These tomatoes were taken off the market shortly after their introduction.
1996	Commercial cultivation of genetically engineered soya in the United States by Monsanto, and first shipments exported to Europe.

When genetically engineered organisms were first released in the US, the controversy they caused was similar to that in Europe today. There were for instance vigorous protests on the release of genetically engineered bacteria (ice-minus). However, in the US, the interests of the agribiotech companies gained much more support in years after the first releases than was the case in Europe.

There are a number of reasons for this. Firstly, the agricultural sector in the United States today is considerably more industrialised than in most regions of Europe. Herbicide-tolerant genetically engineered crops appeared to offer a solution to the problems faced by US agriculture, which has long been characterised by large-scale monocultures. Even in the 1990s, the cultivation of soybeans was coming under pressure from weeds that were resistant to many of the herbicides available at the time[1]. The introduction of the Roundup Ready soybean provided Monsanto with the first-ever opportunity to use the active ingredient glyphosate in soybean cultivation.

At the same time, Roundup Ready soybean cultivation was an example of a new business model. Monsanto had a patent for genetically engineered seed and for the herbicide glyphosate and could therefore sell its products in a twin pack. Unlike Europe, there were companies in the USA that were able to make money out of genetic engineering at a fairly early stage, even though the marketing of the Flavr-Savr tomato in 1994/1995 turned out to be an economic disaster for the US company, Calgene. The tomatoes were too soft when they were ready to be harvested and were unpopular with consumers.

1 http://www.weedscience.org

Backed by the US government, legislation in the United States has been very much tailored to the interests of companies. The United States has no specific authorisation procedure for genetically engineered organisms or any labelling rules for foodstuffs or co-existence rules for crop cultivation.

Developments in the United States have had a significant knock-on effect in many other parts of the world, particularly in North and South America. The repercussions have also been felt on markets in the EU – albeit to a lesser extent than in the United States.

This report provides an overview of developments in the United States, followed by a number of recommendations for the EU based on this overview.

2. Overview of releases and cultivation of GE crops in the United States

Since 1996, the surface area of arable land devoted to the cultivation of genetically engineered crops in the United States has increased significantly. According to Industry figures for 2011 (www.isaaa.org), 69 million hectares of the arable land in the United States were planted with genetically engineered crops. The crops authorised were maize (corn), soybean, cotton, rapeseed, sugar beet, alfalfa, papaya and squash. According to Benbrook (2012a), the share of glyphosate-resistant genetically engineered soybeans on the market is at 60%.

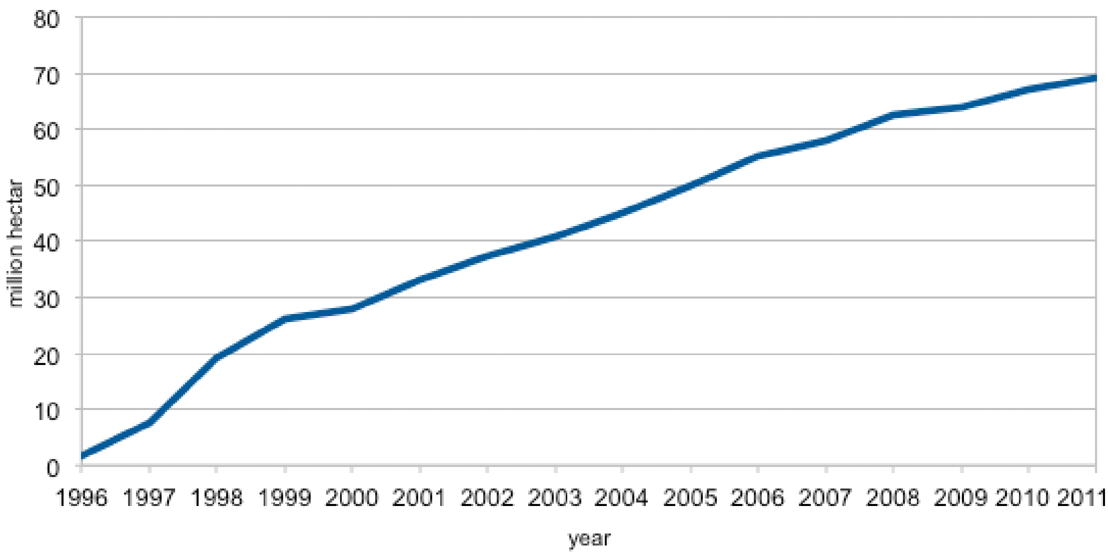

Figure 1: Cultivation figures for genetically engineered crops in the United States (source: www.isaaa.org)

According to statistics of the US Department for Agriculture (USDA), genetically engineered plants cover around 90 percent of the cultivation in cotton, soybeans and maize[2].

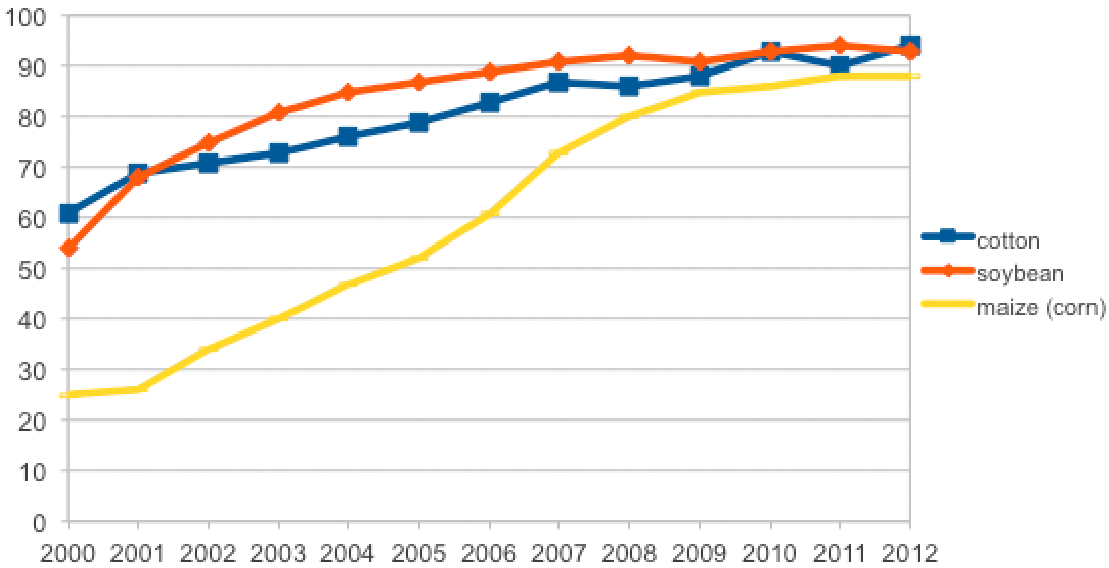

Figure 2: Percentage of genetically engineered plants in the species maize, soybean and cotton from 2000-2012 (source: http://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us.aspx)

The USDA[3] as well as the Biosafety Clearinghouse[4] provide an overview of genetically engineered crops that are authorised in the United States. According to their figures, around 100 so-called events are authorised for cultivation and/or import. There is, however, no existing registration of so-called stacked events produced by cross- breeding genetically engineered plants.

No conclusions can be drawn from this to which extent these plants are actually grown commercially. In practice, soybeans, maize and cotton are grown extensively (see above). They account for more than 90 percent of the overall number of genetically engineered plants cultivated in the US. Furthermore, oilseed rape, sugar beet, squash, alfalfa and papayas have to be mentioned. Also in the US, the number of genetically engineered plant species cultivated mainly for usage in food (and not feed) is very low. There are some genetically engineered potato, wheat, rice and tomato but they are not grown commercially because they lack sufficient support from retailers and food producers.

2 http://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us.aspx

3 http://www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml#not_reg, http://usbiotechreg.epa.gov/usbiotechreg/database_pub.htm

4 http://bch.cbd.int/database/results/?searchid=564348

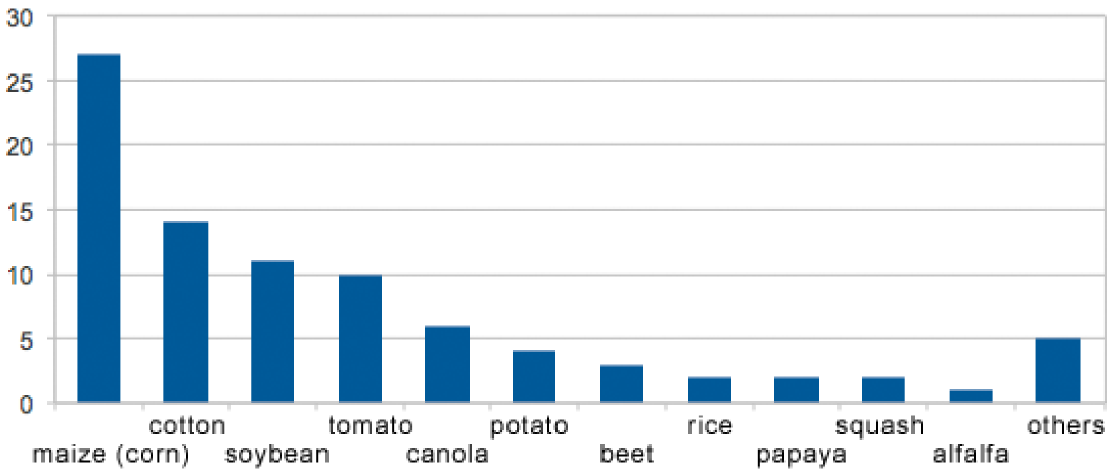

Figure 3: Overview of genetically engineered plants authorised in the US, categorized in species. These figures do not provide any information about the actual cultivation for these crops Source: USDA, http://www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml#not_reg

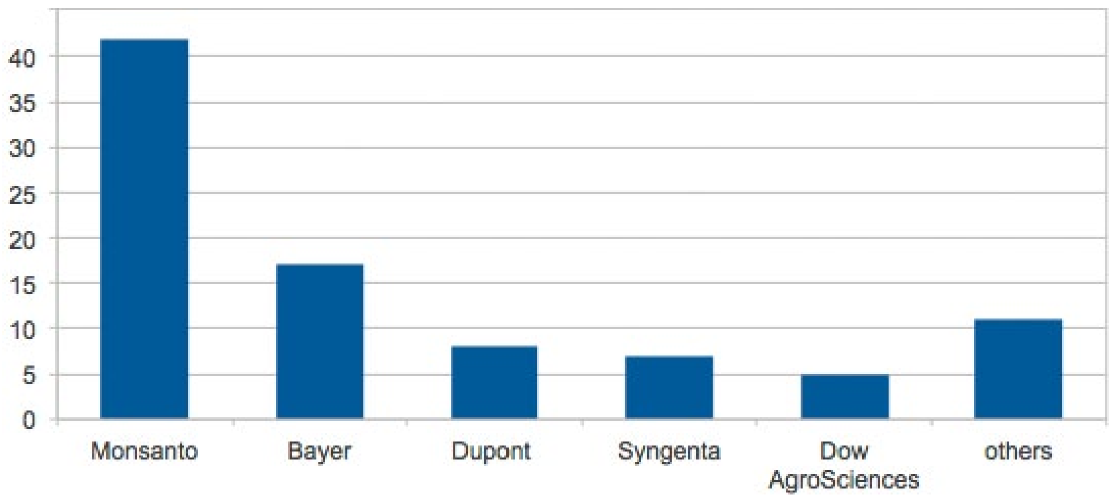

Figure 4: Overview of genetically engineered plants authorised in the US, categorised to companies. These figures do not provide any information about the actual cultivation for these crops Source: USDA, http://www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml#not_reg

3. Impact on farmers

In light of the prevailing conditions in US agriculture, genetically engineered plants initially allowed US farmers to actually make time savings, to further rationalise farming and to make cost savings in some areas. However, these advantages largely evaporated if the crops were cultivated for a prolonged period, and some of the initial advantages even became disadvantages.

3.1 Impact of the cultivation of herbicide-tolerant crops

According to studies carried out by Brookes & Barfoot (2012), who have close ties with the biotech industry and who regularly promote the benefits of genetically engineered crops, cultivating herbicide-tolerant crops has, among others, the following advantages:

- Increased management flexibility (…) This not only frees up management time for other farming activities but also allows additional scope for undertaking off-farm, income earning activities.
- In a conventional crop, post-emergent weed control relies on herbicide applications after the weeds and crop are established. As a result, the crop may suffer "knock-back" to its growth from the effects of the herbicide. In the GM HT crop, this problem is avoided because the crop is tolerant to the herbicide.
- Facilitates the adoption of conservation or no-tillage systems. (…)
- Improved weed control has contributed to reduced harvesting costs — cleaner crops have resulted in reduced times for harvesting (…).

In reality, most observers agree that, under the conditions prevailing in US agriculture, cultivation of herbicide-tolerant crops can help farmers make time savings and enables them to be more flexible in their use of herbicide products. They can use herbicides on their fields pretty much when they see fit and can even spray their crops from planes on to larger areas – the genetically engineered crops survive their toxic shower without damage, while non-GE crops die.

Herbicide-tolerant crops facilitate the use of no-tillage systems, can save time for the farmers and have a positive impact on soil erosion and the CO_2 balance. However, there are also drawbacks to no-tillage and ground conservation systems (including those systems that do not make use of herbicide-tolerant crops), which can lead, under certain circumstances, to lower yields and higher levels of pest infestation. Further, in no tillage system is carbon retention higher in the upper layers of the soil, but reduced in medium and lower layers. (Höper & Schäfer, 2012; Gensior et al., 2012).

The advantages of cultivating herbicide-tolerant crops under industrial farming conditions depend on the herbicide having a real weed control effect. In the case of Glyphosate – the herbicide that is most often used in the cultivation of genetically engineered crops – a large number of weeds have adapted to herbicide-spraying.

Up until 2000, the assessment given by Monsanto to the US authorities was incorrect. In the application for cultivation of maize NK603 (which was accepted) Monsanto explains[5] that:

> *"Although it cannot be stated that evolution of resistance to glyphosate will not occur, the development of weed resistance to glyphosate is expected to be a very rare event because:*

5 http://www.aphis.usda.gov/brs/aphisdocs/00_01101p.pdf

1. weeds and crops are inherently not tolerant to glyphosate, and the long history of extensive use of glyphosate has resulted in few instances of resistant weeds;

2. glyphosate has many unique properties, such as its mode of action, chemical structure, limited metabolism in plants, and lack of residual activity in soil, which make the development of resistance unlikely;

3. selection for glyphosate resistance using whole plant and cell/tissue culture techniques was unsuccessful, and would, therefore, be expected to occur rarely in nature under normal field conditions."

This assessment was apparently incorrect. Over recent years, the 'Weedscience' database (http://www.weedscience.org) has increasingly recorded the emergence of new resistant weeds across the United States. Either these weeds can no longer be eradicated using glyphosate, or greater quantities have to be applied to do so. In the United States, as of October 2012, 13 resistant weeds had been recorded in 31 states. The figure below shows the aggregate figures for the emergence of resistant weeds in the respective states.

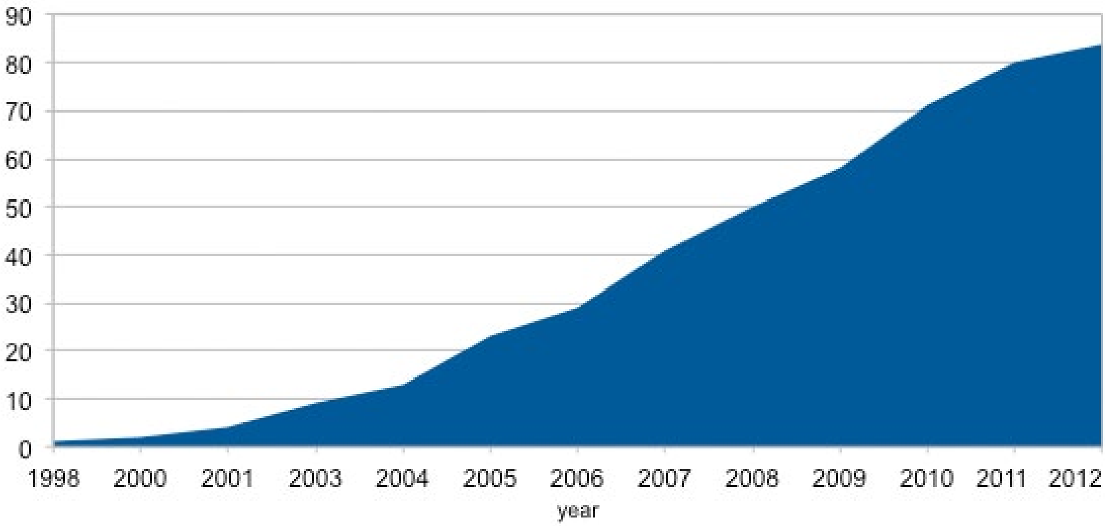

Figure 5: Number of registered herbicide-resistant weeds per state from 1998 to 2012 (aggregate figures).

As a result, both the amount of time spent on herbicide application and the quantities used increase thereby diminishing the advantages cited by Brookes and Barfoot (2012) (see also Bonny, 2011). Benbrook (2012a) estimates that herbicide-resistant weeds have already blighted around 20 to 25 million hectares of arable land in the United States. Benbrook (2012a) shows that, such cases then require time-consuming and costly counter measures. These include using larger quantities of glyphosate, applying additional pesticides, more regular ploughing and hand weeding. Benbrook also refers to calculations made by the US company DowAgro, which show that the costs of weed control have increased by up to 100%.

According to figures published by the US Environmental Protection Agency (EPA) relating to pesticide application, and figures published in 2011 relating to glyphosate use between 2001 and 2007 (Grube et al., 2011), the volume of pesticides used during this period doubled, while the share of genetically engineered crops increased by 75% (Source: www.isaaa.org). Comparing these figures provides plausible evidence that more glyphosate per hectare was used in fields where genetically engineered crops were

grown. Since 2007, there has been an increase of the amount of arable land affected by glyphosate-resistant weeds and the number of resistant weeds has once again increased significantly (see above). Therefore, one must assume that the trend of increasing the application of glyphosate has continued.

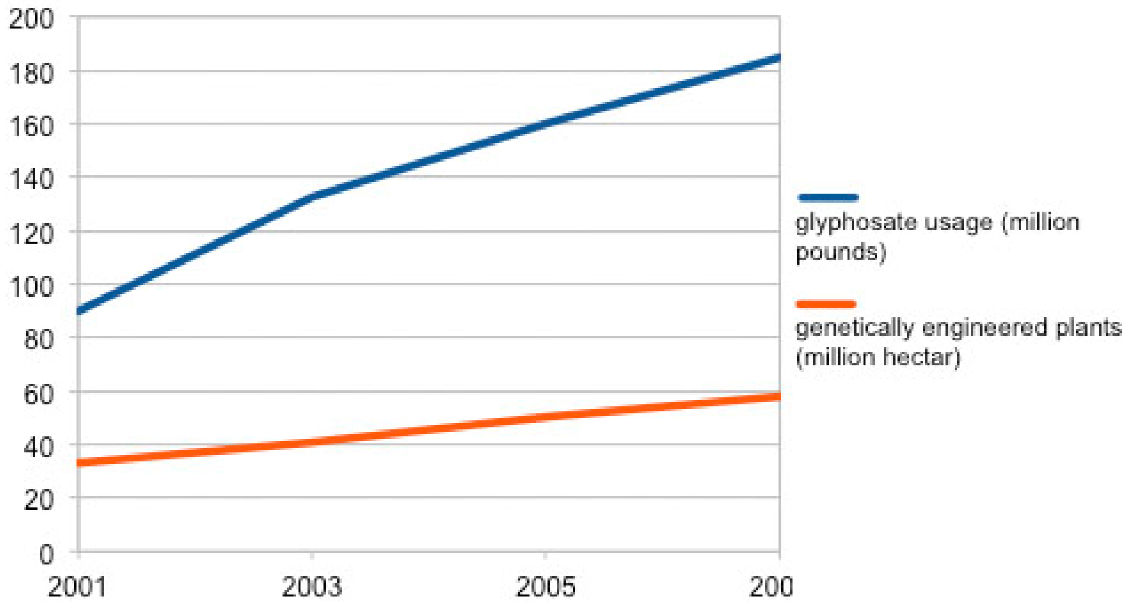

Figure 6: Comparison of increased glyphosate application (Source: Grube et al., 2011) with the figures for genetically engineered crops grown in the USA (source: www.ISAAA.org).

According to Benbrook (2012a), in the period from 1996 to 2011, herbicide application on herbicide-resistant crops increased by 239 million kg and 70% of this increase is attributable to the cultivation of genetically engineered soybeans.

So far, US agriculture appears to have been largely unable to develop alternatives to this 'arming up in the fields'. There are structural reasons for this since the seed industry in the United States, particularly in the soybean, maize and cotton sectors, is controlled by the agro-chemical industry or in other words, companies such as Monsanto, Dupont, Syngenta and DowAgroSciences dominate business in this industry. They are not interested in finding alternatives. The market leader, Monsanto, derives huge turnover from this industry- between 2010 and 2011, its turnover increased by 13% to almost US$ 12 billion[6].

In future, developments in the USA will probably be heavily influenced by agro-chemical companies and alternative cultivation methods that effectively reduce the amount of pesticide spraying will continue to be shunned. Companies like Monsanto, DowAgro and Dupont are developing new genetically engineered crops that are resistant to other pesticides, such as Dicamba or 2,4 D (Mortensen 2012).

As a result, more pesticides will be used and weeds will develop new forms of resistance. Weedscience's database already lists over 200 different weed varieties that have developed a resistance to a whole range of pesticides.

6 http://www.finanzen.net/bilanz_guv/Monsanto

If products such as Dicamba and 2,4 D-resistant crops are introduced, the pressure on other farmers to fall into line will increase. Even small quantities of herbicides that are blown onto neighbouring fields can cause significant damage to those fields (Mortensen et al., 2012). These toxins are extremely volatile and, even in small concentrations, can hamper crop growth. To protect themselves against damage due to herbicide drift, other farmers might feel pressured to also grow plants that are tolerant to 2,4 D and / or Dicamba. According to US authorities (AAPCO, 1999 & 2005), damage due to the drift of 2,4 D is already the most frequent reason for liability cases amongst neighbouring farmers.

This is driving US agriculture ever further into an extreme form of industrialisation that is having an increasing impact on people and the environment. The cost of changing the system is on a steep upward spiral.

3.2 Consequences of cultivating insecticide-producing crops

Genetically engineered maize crops that produce a Bt-based toxin have been commercially cultivated since 1996. The acronym Bt is short for *Bacillus thuringiensis*, which are soil bacteria that naturally produce a broad range of toxic substances (Schnepf, 1998). Some of these toxic substances are repellents that are particularly effective against insects such as *lepidoptera* (butterflies) larvae, as well as against *hymenoptera* (such as mosquitoes) or beetle larvae (*coleoptera*).

Bt-based toxins in their natural form are also used as a sprayed insecticide. The structure and mode of action of the toxin in the crops is partially modified compared with this traditional use of the toxins (Hilbeck & Schmidt, 2006). It is also present in the fields throughout, and even after, the vegetation period. In its sprayed form, exposure to sunlight rapidly breaks the toxin down.

After the introduction of Bt seeds at the end of the 1990s, serious problems were encountered in large-scale cultivation. Pest insects adapted to (the cultivation of) cotton and maize crops. Resistance to the toxins was observed and there are records of new pest emerging (overview Then 2010a). As a result, further toxins designed to repel pest insects were incorporated into the crops to delay the emergence of resistance.

According to industry figures (Edgerton et al., 2012), in 2010 around half of all arable land in the United States, i.e. 17.8 million hectares, was planted with insecticide-producing, triple-stack maize crops. Triple-stack crops are produced by crossing genetically engineered crops. These are generally referred to as 'stacked events' (a combination of traits of genetically engineered crops). A 'triple stack' has three distinct traits:

(1) Tolerance to herbicide

(2) Toxic to pest insects which damage the crop above the soil

(3) Toxic to rootworm which attack the crops in the soil.

According to industry (Edgerton et al., 2012), cultivation of triple-stack maize helps secure harvest yields. In particular, according to this argument, the yields of farmers growing genetically engineered maize are higher than those of conventional farmers in years when high levels of pest infestation are observed.

The triple stack that currently contains the most DNA constructs is SmartStax, a genetically engineered maize that is produced jointly by Dow AgroSciences and Monsanto. It produces six different insecticide-producing toxins, one of which (Cry1A.105) is artificially synthetised. The crops are also tolerant to the weed killers glyphosate and glufosinate.

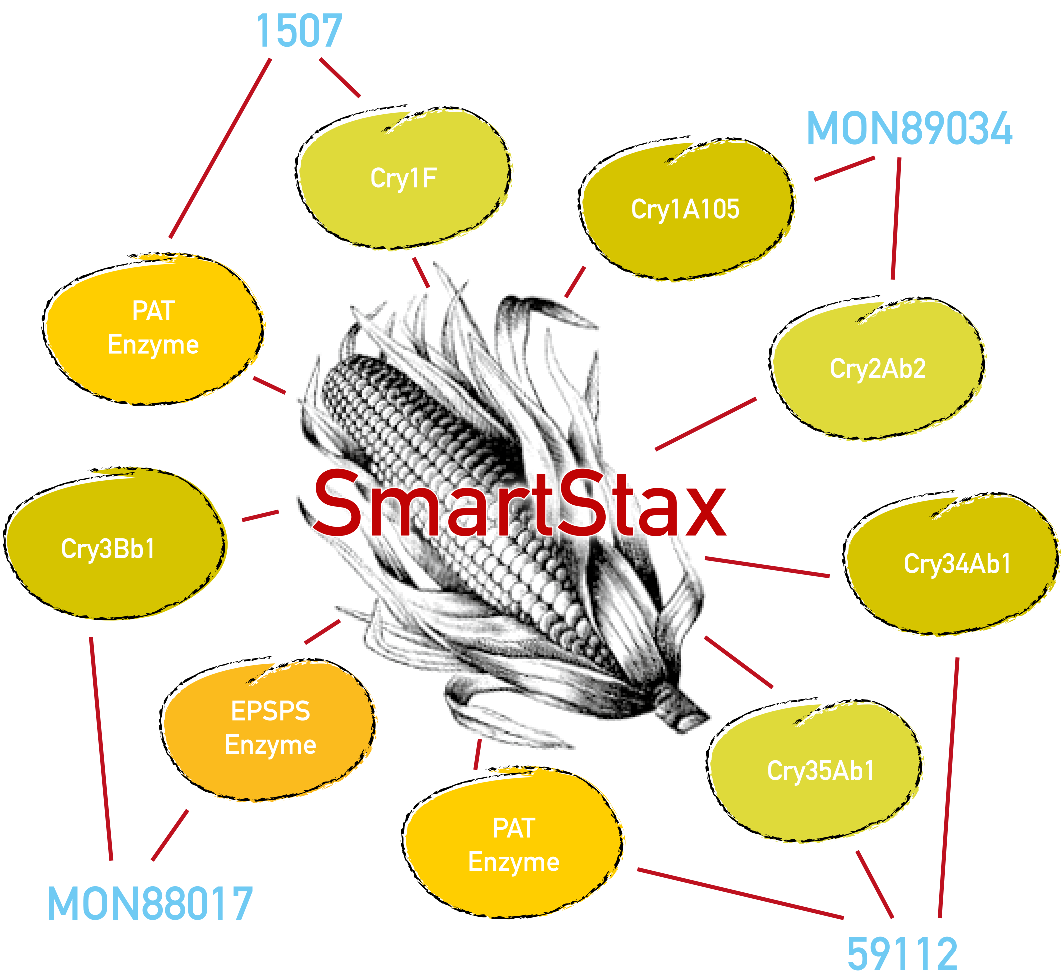

Figure 7: SmartStax, produced by Monsanto and Dow AgroSciences. This maize is a combination of four genetically engineered events (MON88017, MON89034, DP59122, DP1507), produces six insecticide-producing toxins (Cry toxin is derived from several strains of *Bacillus thuringiensis*, one of which, Cry1A105, is synthetically manufactured) and is tolerant to two herbicides (glufosinate through the PAT enzyme and glyphosate through the EPSPS enzyme) (source: Testbiotech).

The western bean cutworm: a pest on the rise

Generally speaking the term 'pest replacement' is used to designate the emergence of new pests in place of existing ones. This phenomenon often occurs in agriculture when the same pesticides are used for many years on large tracts of land to eradicate specific pests, thus creating ecological niches for new pests. Pest replacement and the development of resistant pests are the consequence of a strategy designed to permanently displace pests or even eradicate them. This phenomenon is particularly likely to occur with the cultivation of Bt crops, as the toxin is present in the field throughout the vegetation period, and therefore the pest insects are continuously in contact with the toxin throughout the year.

The western bean cutworm is an extreme example of the consequences of Bt crop cultivation. This pest insect was originally only a peripheral phenomenon in maize cultivation. However, since 2000, it has been observed that genetically engineered maize crops that produce Bt toxins are being attacked particularly by the caterpillar of the western bean cutworm (*Striacosta albicosta*) (Rice, 2000, O'Rourke & Hutchison, 2000).

Since 2000, it has continued to spread across a number of US Federal States in the Western Corn Belt, causing considerable economic damage. Catangui & Berg (2006) have noted its spread in South Dakota. According to them, the pest spread on such a massive scale in that state in 2000 that it caused considerable economic damage, and continued in the same vein in subsequent years. Similar phenomena have also been observed in Iowa, Illinois and Missouri (Dorhaut & Rice, 2004).

Until 2008, damage caused by the Western bean cutworm was recorded in almost all States in the Western Corn Belt. The states affected include Iowa, Missouri, Illinois, Minnesota, Wisconsin, Indiana, Michigan and Ohio (Eichenseer et al, 2008). Originally, the pest was more or less restricted to Nebraska. Michel et al. (2010) write:

> *'Western bean cutworm was only sporadically found in western Iowa before 2000 and the first economic damage in Iowa cornfields was reported in 2000. During 2000–2009, the eastward expansion accelerated. Western bean cutworm adults have now been collected in 11 additional states and provinces since 1999, spreading from western Iowa into eastern Pennsylvania and southern Quebec.'*

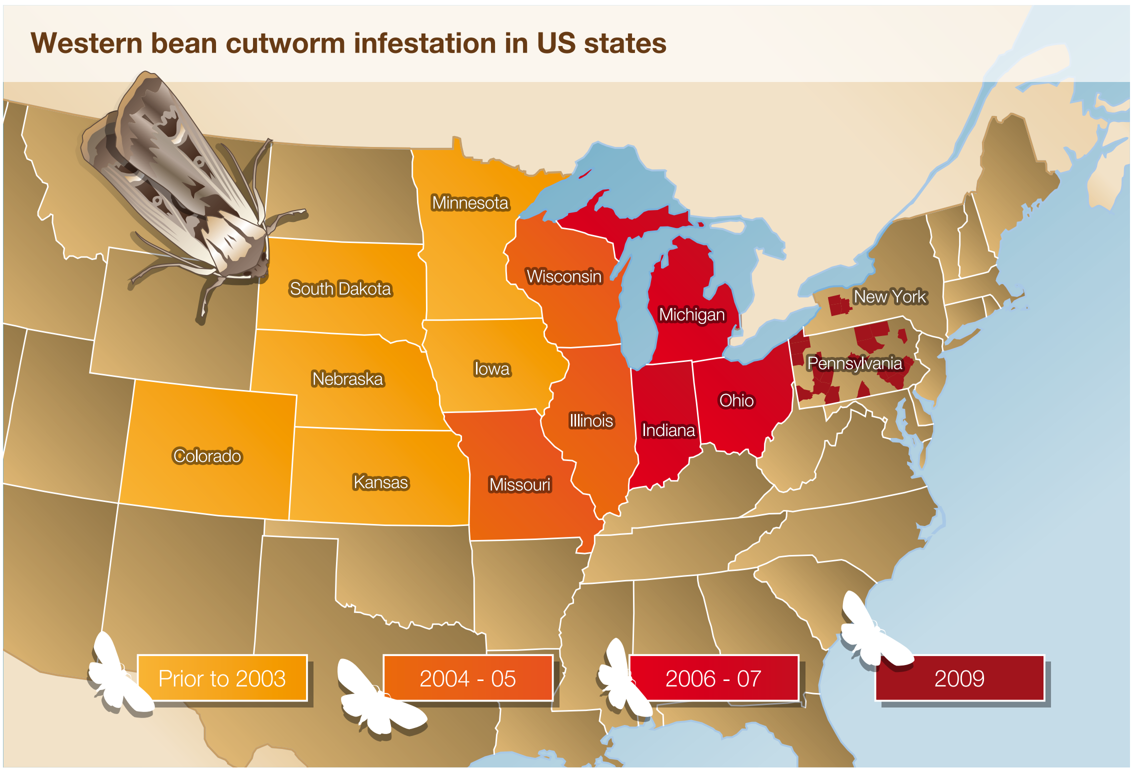

Figure 8: Spread of the western bean cutworm across the US Corn Belt 2000-2009 (source: Testbiotech).

Several authors have explained at great length how the cultivation of genetically engineered Bt maize has caused the new pest to spread (Then 2010a). In 2010, laboratory tests demonstrated that a competitor of the Western bean cutworm, the corn earworm, has been eradicated as a result of the cultivation of insecticide-producing maize, thereby creating an ecological niche that allows for the spread of the Western bean cutworm (Dorhout & Rice, 2010). As a result, the western bean cutworm was able to spread in maize-growing areas where Bt maize is cultivated.

In 2011, experts with links to industry put forward other possible explanations for the spread of the Western bean cutworm, such as climate change (Hutchison et al., 2011), but they have still not provided proof of their theories. In contrast, the mechanisms of pest replacement have been well documented.

The counter-strategy deployed by industry has entailed combining several toxins in the genetically engineered crops. SmartStax contains three toxins (Cry1A.105, Cry2Ab2 und Cry1F) that repel caterpillars of pest insects belonging to the butterfly family (*Lepidoptera*), and which damage the plants above ground. The Cry1F toxin is designed particularly to protect the crops from the Western bean cutworm (*Striacosta albicosta*) – at least as long as the pests have not adapted to this toxin.

But even if the Western bean cutworm could be controlled by cultivating SmartStax, US agriculture would still be faced with the spread of the bean cutworm. Having found a favourable environment to spread on a massive scale in maize fields, the pest is also spreading in the affected regions in fields planted with beans. As a result, further action has to be taken in these fields to fight the pest and therefore more insecticides have to be applied (Michel et al., 2010).

The rootworm: an even greater menace as a result of Bt maize?

Similar problems are being encountered with pests that damage the plants below soil. Several publications show that the rootworm (*Diabrotica virgifera virgifera*) is increasingly adapting to Bt maize. These studies have demonstrated the swift spread of pesticide-resistant rootworm in regions where genetically engineered maize is grown (Gassmann et al., 2011; Gray, 2011).

It is of particular concern that the pests could develop into an even greater menace as a result of the cultivation of genetically engineered crops. A US laboratory study (Oswald et al., 2012) has shown that genetically engineered maize could contribute to pest insects spreading even more quickly. According to the results of the study, larval development in resistant insects is accelerated and more pest insects are produced in a shorter space of time. This can cause the pest insects to spread even more quickly in the fields, as a result of growing Bt maize.

3.3 Costs and benefits of growing genetically engineered crops for farmers

According to Brookes and Barfoot (2012), genetically engineered crops are grown to secure significantly larger harvests and significantly more economically lucrative yields. However, these and other such perceptions are misleading. They make no distinction between the yield increases achieved as a result of genetic engineering and those achieved as a result of other reasons. In reality, US agricultural yields have increased in recent years because the harvest prices obtained by farmers have increased. These higher prices can be attributed to developments such as higher demand for crops to manufacture agrofuel or lower global harvest yields and the resulting higher prices for agricultural raw materials.

However, the official data of the USDA (US Department for Agriculture)[7] relating to genetically engineered crops does not point to either increasing harvest yields or any significant reduction in the cost of chemicals for pesticides. In contrast, seed prices have increased significantly.

7 http://www.ers.usda.gov/Data/CostsAndReturns/testpick.htm

The graphs below provide an overview of harvest yields and pesticide and seed prices for maize (corn), soybean and cotton between 1996 and 2011. When interpreting these figures, it should be borne in mind that the prices for glyphosate have fallen since the expiry of a patent owned by Monsanto. The slight savings made on pesticide costs should not be attributed to the use of lower quantities of herbicides, but rather to lower prices for pesticides such as Roundup.

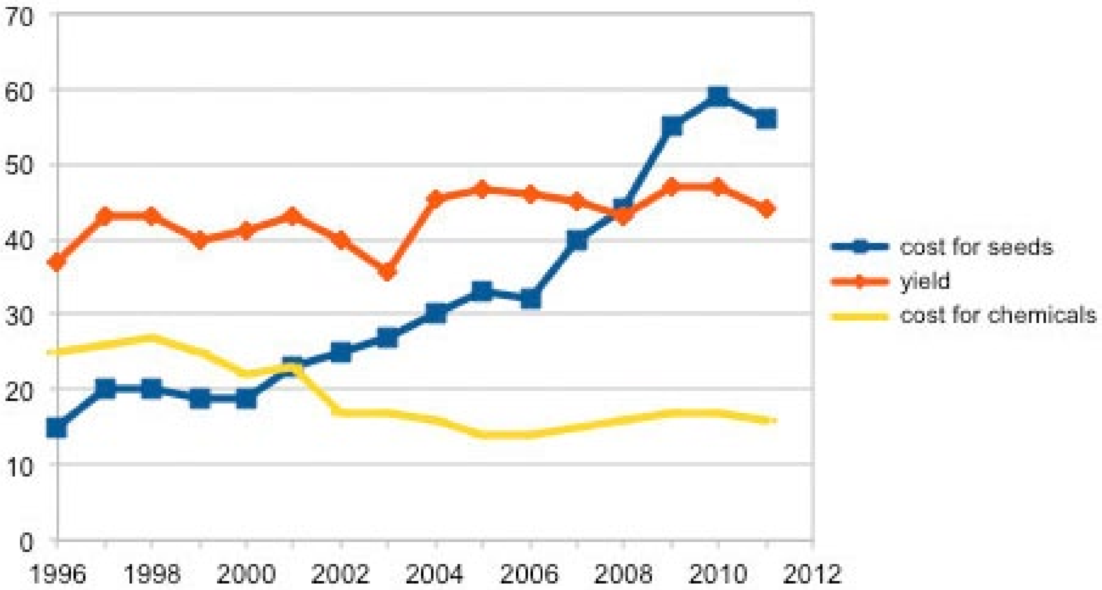

Figure 9: Development of cost for seeds (seed, US dollar per acre), cost for chemicals (chemicals, US dollar per acre) and yields (yield, bushel per acre) for **soybean** cultivation in the United States from 1996-2011 (source: USDA data)

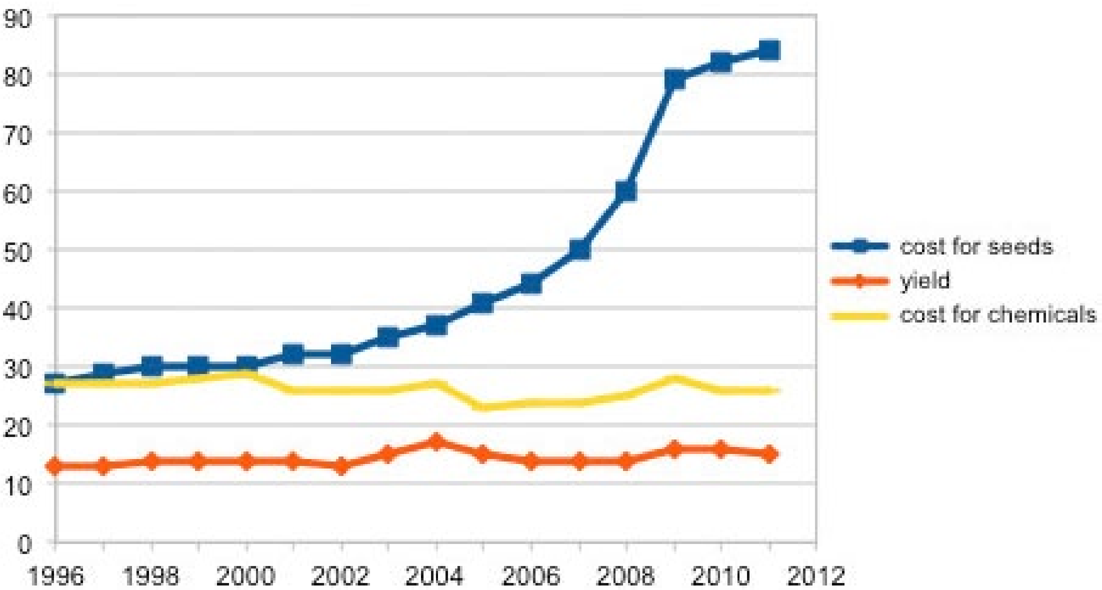

Figure 10: Development of cost for seeds (seed, US dollars per acre), cost for chemicals (chemicals, US dollars per acre) and yields (yield, bushel per acre, values equal to 10% of actual yields) for **maize** (**corn**) cultivation in the United States from 1996-2011 (source: USDA data)

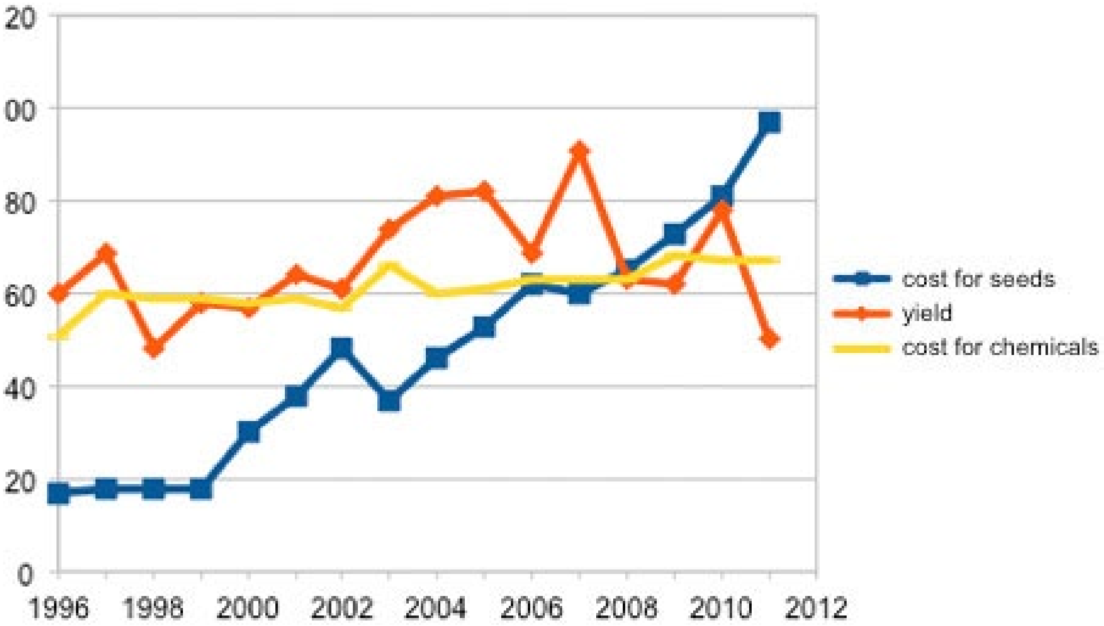

Figure 11: Development of cost for seeds (seed, US dollars per acre), cost for chemicals (chemicals, US dollars per acre) and yields (yield, pounds per acre, values equal to 10% of actual yields) for **cotton** cultivation in the United States from 1996 to 2011 (source: USDA data)

These data do not enable us to ascertain that yields have increased or a significant savings effect has been created since the introduction of genetically engineered seed. In contrast, the costs for seeds have increased significantly.

According to Benbrook (2012a), the costs for genetically engineered seed have increased significantly more than the prices for conventional seed:

> *"The markedly higher cost/hectare of herbicide-resistant seeds must be added to the higher herbicide costs noted above to more fully reflect the added costs associated with HR technology. The cost of a bushel of conventional, not-GE soybean seed increased during the GE-crop era from $14.80 in 1996 to $33.70 in 2010, while a bushel of GE soybean seed cost, on average, $49.60 in 2010 (all seed price data derived from USDA data) [33]. Accordingly, the cost of GE soybean seed in 2010 was 47% higher per bushel than non-GE seed. In the case of corn, conventional seed prices rose from $26.65 per acre planted in 1996 to $58.13 in 2010. The average cost of GE corn seed per acre in 2010 was $108.50, with some GE cultivars selling for over $120 per planted acre. Hence, GE corn seed costs per acre were about double the cost of conventional seed."*

An earlier publication by Brookes and Barfoot (2008) shows that the additional seed cost in insecticide-producing crop cultivation outweighed the pesticide cost saving year on year for the period 1996-2006 – since that period the cost of seed has once again significantly increased.

Appendix 1. Examples of Farm Income Methodology Application

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Table A1. Farm-level income impact of using GM IR maize in the United States, 1996

Year	Farm-level price of maize ($/ton)	Base yield (tons/ha)	Insecticide cost saving*	Cost savings (net after cost of technology)*	Net increase in farm gross margin income*	Area of GM IR maize (million ha)	Increase in farm income at a national level ($ millions)
1996	107.0	7.18	24.71	-9.21	29.20	0.300	8.76
1997	96.0	7.52	24.71	-9.21	28.81	2.446	70.47
1998	76.0	8.38	20.30	-4.80	27.04	6.196	167.58
1999	72.0	8.42	20.30	-4.80	25.51	8.111	206.94
2000	73.0	8.51	22.24	-6.74	24.32	6.117	148.77
2001	78.0	8.59	22.24	-6.74	26.76	5.821	155.87
2002	93.0	8.06	22.24	-6.74	30.74	7.822	240.45
2003	87.0	8.80	22.24	-6.74	31.54	9.225	291.00
2004	81.1	9.91	15.88	-6.36	33.82	10.714	363.41
2005	78.7	9.13	15.88	-1.42	34.52	11.584	399.91
2006	119.3	9.59	15.88	-1.42	55.78	12.679	707.23

Figure 12: According to Brookes and Barfoot (2008), US farmers have made insecticide cost savings, but this did not offset the additional costs for seed (see column 5, 'Cost savings (net after cost of technology)').

4. Impact on the seed market

The higher costs for seed are due, on the one hand, to a technology premium that the companies charge for their patented genetically engineered seed. The seed markets for maize and soybean are highly concentrated and therefore competitors largely excluded. The biotech companies can to a substantial extent set the prices for seed as they see fit.

According to the ETC Group of Experts (ETC, 2011), the US company Monsanto, which is the market leader in sales of genetically engineered seed, currently has a 27% share of the global (GE or non-GE) seed market. In second place is the US company Dupont. The two companies together have a market share of 44%. Neither company is a conventional seed grower. They only entered the seed market when genetic engineering started to provide new opportunities to control markets through patents (OECD, 1992).

In the United States, the seed markets for soybean and corn in particular are controlled by a few companies. According to Hubbard (2009), in 2008 Monsanto controlled some 60% of the US maize (corn) seed market, followed by Dupont with around 30% and the Swiss company Syngenta in third position, with around 10%. Some 80% of fields were planted with Monsanto's genetically engineered maize.

World's Top 10 Seed Companies

Company	2009 seed sales US $ millions	% of Market share
1. Monsanto (USA)	7,297	27%
2. DuPont (USA)	4,641	17%
3. Syngenta (Switzerland)	2,564	9%
4. Groupe Limagrain (France)	1,252	5%
5. Land O' Lakes/Winfield Solutions (USA)	1,100	4%
6. KWS AG (Germany)	997	4%
7. Bayer CropScience (Germany)	700	3%
8. Dow AgroSciences (USA)	635	2%
9. Sakata (Japan)	491	2%
10. DLF-Trifolium A/S (Denmark)	385	1%
Total Top 10	**$ 20,062**	**73%**

Figure 13: World's Top Ten Seed Corporations. Source: ETC 2011

The limited number of seed suppliers means that US farmers often lack real choice. In particular, the choice of non-GE seed varieties has become much more limited in recent years, as shown in an overview in Binimelis et al. (2012).

Table 2: Number of GE and non-GE corn varieties in the USA (source: Binimelis et al. (2012) / Monsanto

Corn	Number of varieties in 2005	Number of varieties in 2010	Percentage change (2005-2010)
Genetically engineered varieties	5,695	6,079	+ 6.7%
Conventional varieties	3,226	1,062	- 67%

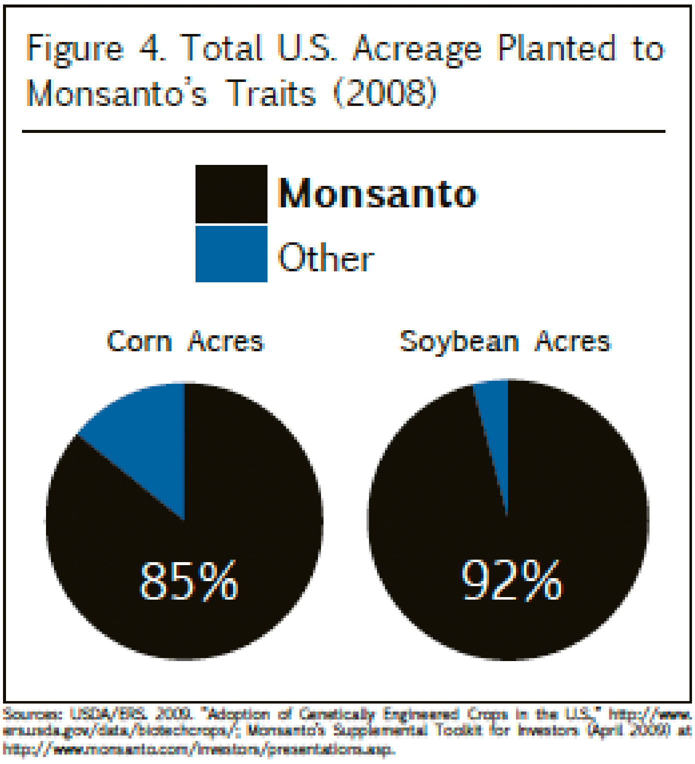

Figure 14: Monsanto's market share of the soybean and corn seed markets in the United States and percentage of acreage planted with Monsanto seeds in 2008 (the genetically engineered crops are also sold, under a licence agreement, by other companies) (source: Hubbard, 2009).

The lack of competition between the small number of large companies that dominate the market and that often conclude licence agreements between themselves (Howard, 2009) serves to further push up prices. The rising prices for seeds are further driven by introduction of "stacked events" like maize SmartStax, because farmers pay more for the combination of technical traits[8]. Monsanto's strong market position is due to the fact that it has bought up traditional seed-growing companies and biotech competitors. Howard (2009) provides an overview of the Monsanto empire, which shows clearly that the company is focusing not just on soybean, corn and cotton, but also on vegetable breeders.

8 http://www.organic-center.org/reportfiles/Seeds_Final_11-30-09.pdf

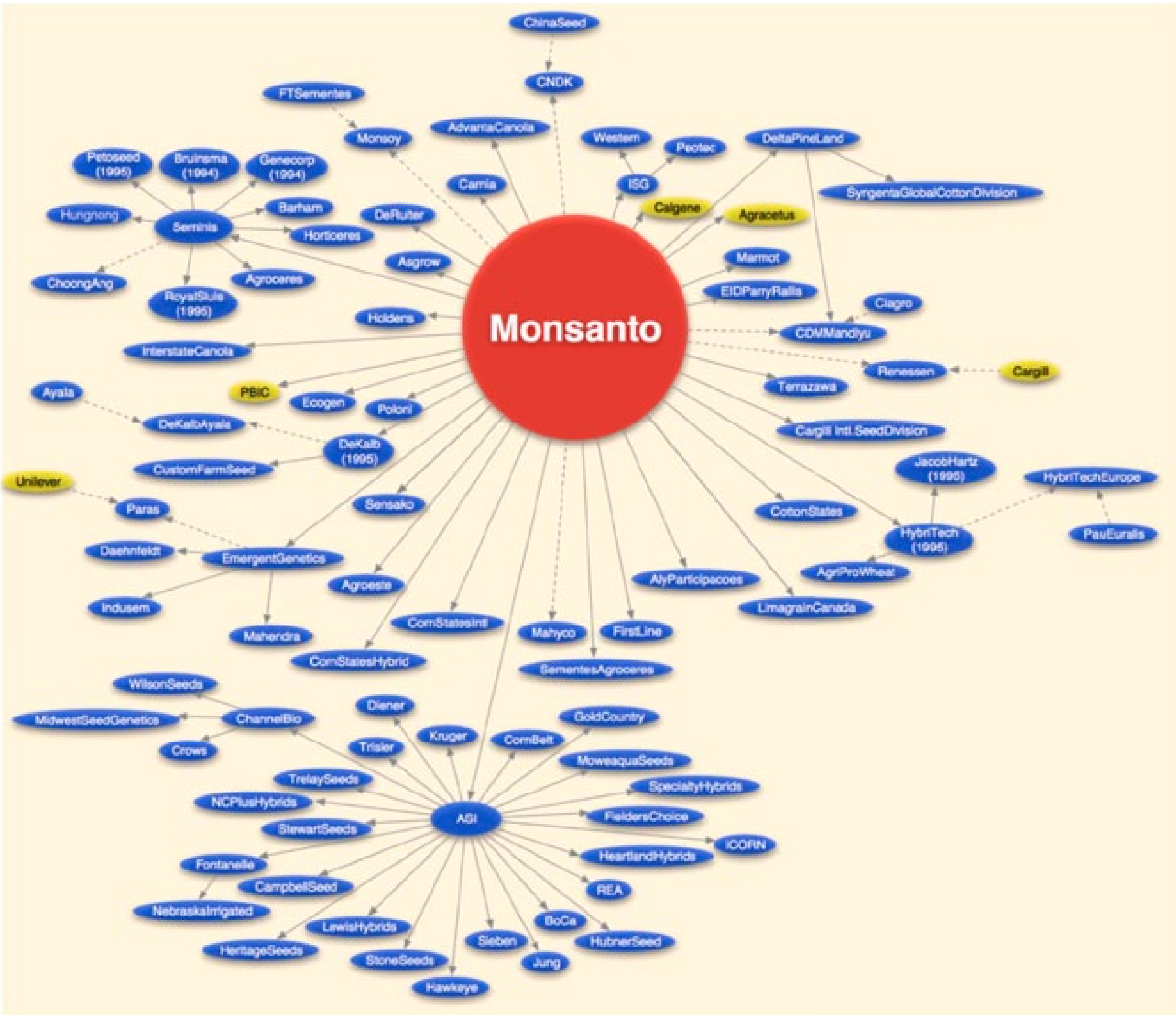

Figure 15: Network of companies owned by Monsanto. The company owns large corn breeders, such as DeKalb, as well as the world's biggest vegetable breeder, Seminis (source: Howard, 2009).

Companies like Monsanto also prevent farmers from being able to use seed from their own harvests for replanting. Howard (2009) states that the share of soybean seed used by farmers from their own harvests for replanting fell from 63% in 1960 to 10% in 2001. A report by the Center for Food Safety in the United States documents over 100 cases where farmers have been accused by Monsanto of breaching their patents (Center for Food Safety, 2005). According to news agency Bloomberg, Dupont is planning to send private detectives into the fields of the farmers[9].

9 http://www.bloomberg.com/news/2012-11-28/dupont-sends-in-former-cops-to-enforce-seed-patents-commodities.html

5. Impact on producers of non-GE crops

Cultivation of genetically engineered crops in the United States regularly causes contamination in the food chain. As there is no food labelling requirement in the United States, data relate first and foremost to those cases of contamination relating to unauthorised products.

A report by the United States Government Accountability Office (GAO) from November 2008 lists six well-known cases of unauthorised GE varieties. The report estimates the resulting damage (for the USA alone) at billions of US dollars.

Table 3: Overview of high-profile cases of contamination caused by unauthorised genetically engineered crops in the USA, Source: GAO, 2008.

Year	Product	Crop	Trait
2000	StarLink	Corn	Insecticide-producing and herbicide-tolerant
2002	Prodigene	Corn	Pharmaceutical protein
2004	Syngenta Bt10	Corn	Insecticide-producing
2006	Liberty Link Rice 601	Rice	Herbicide-tolerant
2006	Liberty Link Rice 604	Rice	Herbicide-tolerant
2008	Event 32	Corn	Insecticide-producing

'StarLink' is a corn variety that produces a Bt insecticide (Cry9c), which is suspected of being potentially allergenic because the toxin can only be broken down slowly during the digestive process. In 2000, because of contamination with StarLink, corn prices fell by 6%. Exports to Japan, the EU, Asia and the Middle East were curbed. This led to losses of around US$ 500 MM for US corn farmers who had not planted any Starlink (Carter & Smith 2003). Further estimates have suggested that the Starlink contaminations cost the US economy around US$ 1 billion in 2001 (Macilwain 2005). Contamination from StarLink was also detected in many other countries.

The economic damage arising from contamination by genetically engineered rice (Liberty Link Rice) produced by Bayer was similarly high. As a result of the seed contamination it caused, Bayer was forced to pay around US$ 750 million in fines to US rice growers in 2011.

Organic farmers from the United States and Europe who grow non-GE crops are also obviously affected by this. Even though they often suffer economic losses as a result of contamination by GE crops, damages claims have been unsuccessful so far. For example, in February 2012, a court in New York rejected a damages claim filed by an organic farmer[10]. Also in the US, demands for the protection of farmers not growing genetically engineered plants, are becoming more vocal. In November 2012, a USDA Commission recommended systematically collecting and examining possibilities for compensation payments (USDA, AC21 Report, 2012).

10 http://www.prwatch.org/news/2012/03/11326/rampant-gmo-contamination-unchecked-judge

6. Impact on consumers

Placing genetically engineered crops on the market broke an unwritten food manufacturing rule. Instead of using traditional, tried-and-tested food manufacturing processes based on the highest possible safety standards, farmers' fields were converted into laboratories and consumers turned into guinea pigs.

Food labelling in the US does not inform consumers about the use of genetically engineered crops. In a bid to prevent any GE-specific labelling requirements, industry (companies such as Dow Chemical, BASF, Cargill, PepsiCo, Coca Cola, Monsanto, Syngenta and Bayer) invested US$ 46 million in California in 2012 to thwart a citizens' petition to establish such a labelling system[11].

The lack of a labelling system means that there is a lack of differentiation between products on the market. Whereas, in the EU, the norm is not to use products derived from genetically engineered plants even in conventional food products, US consumers have to resort to organic or regional products if they want to avoid these foodstuffs.

This in turn also affects agricultural practice. Consumers cannot give clear signals to the market by deliberately choosing to go against developments in agriculture.

6.1 New risks, absence of monitoring of health effects

One of the unintended effects of genetic engineering is that genetically engineered plants can – also case by case in interaction with the environment - produce undesirable compounds and biologically active substances. These may be anti-nutritive substances that affect metabolization of the food constituents during digestion or secondary metabolites that can have a negative impact on health.

New DNA combinations also enter the food chain as a result of genetic engineering which can then be transmitted to animals via animal feed. Such combinations have been observed, for example, in goat's milk (Tudisco et al., 2010), pigs (Mazza et al., 2005; Sharma et al., 2006) and fish (Chainark, 2008; Ran et al., 2009). While the effects of these DNA fragments and their biological activity have long been debated, an unexpected new risk arose in 2011. It was demonstrated that so-called micro-RNAs (miRNA), which are important in terms of the regulation of gene expression, are transmitted from plants to animals, where they can still be biologically active, i.e. they interfere with the natural regulation of gene expression in mammal cells (Zhang et al., 2011).

The small RNA fragments are so stable that they can even survive when food is heated. Just what impact this will have on the risk analysis of genetically engineered crops has yet to be established. The consumption of genetically engineered crops can lead to the transmission of new biologically active constituents, such as miRNA, to humans and animals and can interfere with the regulation of gene expression.

Definitive assessments of the many risks cannot be fully completed. It is therefore, important to examine very closely the effects of crop consumption after marketing authorisation has been granted. However, as there is no labelling requirement and no traceability of products on the US food market, there is no possibility of collecting data on potential health impacts. Back in 2005, the European Commission declared that, based on the available data, it was possible to rule out a link between consumption of such food products and symptoms associated with acute illnesses, but that it was

11 http://www.nytimes.com/2012/11/08/business/california-bid-to-label-genetically-modified-crops.html?_r=0

impossible to ascertain to what extent they increased the risk of the development of chronic diseases such as cancer and allergies:

"As regards food safety, even if some GM products have been found to be safe and approved on a large scale ... the lack of general surveillance and consequently of any exposure data and assessment means that there is no data whatsoever available on the consumption of these products – who has eaten what and when. … in the absence of exposure data in respect of chronic conditions that are common, such as allergy and cancer, there simply is no way of ascertaining whether the introduction of GM products has had any other effect on human health." (European Commission, 2005).

6.2 Increasing exposure to herbicide residues

Growing genetically engineered crops means that consumers are exposed to a different order of pesticides. The crops are tolerant to certain herbicides, such as glyphosate, and the residues and metabolites of these herbicides have become a permanent feature of the resulting food. Until the emergence of GE food, these specific residues were only occasionally encountered. Genetic engineering has led to the permanent exposure of such food to certain pesticide residues on an unprecedented scale. Moreover, the adaptation of weeds to pesticides such as glyphosate, means that we can expect to find increasing residue levels in food in the future. Maximum authorised levels of glyphosate residue are already very high - in soybean, they can be up to 20 mg/kg.

In addition, pesticides like Roundup often contain additives such as polyethoxylated tallow amine (POEA), thought to foster better absorption of the toxins by the crops thereby enhancing their effectiveness. These tallow amines are far more toxic than glyphosate. Their use in German agriculture has therefore been significantly restricted[12], unlike in the United States.

Despite the large-scale use of pesticides in GE crop growing, there is an astounding lack of data relating to residue controls. According to Kleter et al. (2011), there is almost a complete lack of data on residue levels in GE crops:

"While residue data from experimental studies have been used to establish the residue tolerances for the herbicide–crop combinations described above, it would be interesting to compare these tolerances with what is actually measured in the field, i.e. in commercially produced foods. No measurement of the herbicides of interest in the particular crop foods in question is apparently carried out by the centralised or federal pesticide residue monitoring programmes of the EU, the United States and Canada."

Given that, due to the adaptation of weeds, glyphosate is now applied more often and later in the vegetation period, experts like Benbrook (2012a) expect consumers to be increasingly exposed to pesticide residues in the future:

"Heightened risk of public health impacts can be expected in the wake of more intensive herbicide use, especially applications later in the season on herbicide-resistant crop varieties....Applications later in the growing season will be more likely to lead to residues in silage or forage crops. As a result, herbicide residues in milk, meat, or other animal products might become more common."

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12 http://www.bvl.bund.de/DE/04_Pflanzenschutzmittel/05_Fachmeldungen/2010/psm_anwendungsbestimmungen_tallowamin-Mittel.html

The European Food Safety Agency, EFSA, (2011) is assuming that certain residues can be found on a regular basis in the human bloodstream (although there are many other ways of coming into contact with the toxins than by consuming GE crops). In a review of a Canadian publication that stated that residues and metabolites of glyphosate, such as MPPA, had also been found in the bloodstream of pregnant women (Aris & LeBlanc, 2011), EFSA states that these findings are not unexpected:

> *"From the consumer health perspective, the observations described by the authors on the presence of glyphosate and glufosinate in non-pregnant women blood (5% and 18% of the subjects, respectively) and of 3-MPPA in non-pregnant women, pregnant women and the fetal cord blood are not unexpected. It is known that pesticides are generally well absorbed by the gastrointestinal tract and that an exposure to the two herbicides investigated through the consumption of food commodities is plausible."*

Constant exposure to pesticide residues can, even in small concentrations, effect hormone metabolism, thereby disrupting, for example, embryo development and influencing cell division and cancer growth. There have been a whole series of papers published on glyphosate and glyphosate mixtures, which show such effects to be plausible (see overview Then, 2011). It is a matter of concern that, according to the German Institute for Risk Assessment (BfR 2012), that only one long-term study from France focussing on a Roundup product that is readily available on the market has been conducted (Seralini et al., 2012). Pesticide mixtures available on the market contain increasing numbers of additives, such as tallow amine, while the approval tests only examine the substance in its pure form (glyphosate), even though it is never applied in this form in practice. A realistic appraisal of the health risks associated with long-term exposure to these pesticide mixtures appears not to be feasible at the moment. It would appear that further studies are urgently needed. The French study (Seralini et al., 2012), pointed to a significantly higher health risk for rats that were exposed to low levels of Roundup throughout their lifetime.

Constant exposure to herbicide residues, such as glyphosate, can also have indirect health impacts, for example, it can cause changes to the intestinal flora of humans, which can increase the risk of the development of illnesses. It is already known that application of glyphosate can cause changes to the composition of the soil microbial flora (see, for example, EFSA , 2012). Glyphosate is also effective against certain bacteria, such as E. coli (Forlani et al., 1997; Carlisle & Trevors, 1986), and can, in high concentrations, damage the intestinal flora of cattle (Reuter et al., 2007). Even low doses impact the microbial flora of poultry and there is a reduction in the number of beneficial microbes. (Shebata et al., 2012). It is therefore plausible that the permanent application of glyphosate could cause changes to human intestinal flora. This risk has never been assessed to date.

6.3 Residues from insecticides

The persistent residues in foodstuffs also include Bt insecticides. Around a dozen different toxins may be contained in crops, especially in corn (see above). The Bt insecticides in GE crops are only meant to be effective against certain insects and are therefore regarded as harmless to humans and the environment. There are, however, a number of indications that this toxin has a broader impact than was originally thought. Effects have been observed in organisms that the toxin was not designed to have an impact on (Lövei et al., 2009, Hilbeck et al, 2012). Even human cells react to the toxin (Mesnage, 2012). Interactions with other substances have also been observed, which have the effect of increasing

the potency of the insecticide (overview: Then, 2010b). Interactions between the different insecticides, the pesticide residues and other components, such as enzymes and allergenic substances, have however not really been studied yet.

The toxicity of the Bt toxins can also vary greatly. The biological activity of these substances can change as a result of only slight divergences in the protein structure. Even when the biological activity is the same, the potency of the Bt-toxins can be much higher than expected depending on the manufacturer (Saeglitz et al., 2008). There have been no relevant comprehensive studies in this respect, and no standardised methods have been developed to reliably determine the toxin content of these substances (Székács et al., 2011).

6.4 Risk of immune system reactions

Studies have demonstrated on many occasions that GE crops can trigger immune system reactions. Immune system reactions have been observed in fish (Sagstad et al., 2007), pigs (Walsh et al., 2011), mice (Finamore et al., 2008, Adel-Patient et al., 2011) and rats (Kroghsbo et al., 2008), to name but a few examples. Even Monsanto (Monsanto, 2011) notes in its review of current literature that the Bt toxin in GE crops causes immune system reactions in mice (Adel-Patient et al., 2011). It can be assumed that the Bt proteins contribute to this. It is known that many bacterial proteins trigger immune system reactions. Due to the strengthening effect they have on the immune system, some Bt toxins (such as Cry1Ac) are used as adjuvants in vaccines.

It would be risky to also incorporate Bt proteins, such as Cry1Ac, into soybeans (see Testbiotech, 2012). Soybeans already naturally contain a large number of proteins that can cause allergies. If combined with the Bt toxins, these allergic reactions may be exacerbated. Allergenic substances have also been detected in corn. The immune-strengthening effect of Bt toxins could however also have an effect on other food constituents that may be absorbed coincidentally along with them.

In order to perform an allergenic risk assessment, Bt toxins are subjected to so-called digestion tests. These tests measure how long it takes for the proteins to be broken down in artificial stomach acid. These tests suggest that Bt toxins, such as Cry1Ab, which are authorised for use in GE crops, are quickly broken down and therefore only remain in the gastrointestinal tract for a short period, in which case the body's immune system would have barely any time to react to the toxin. Walsh et al. (2011), however, conducted tests on pigs under real conditions, and observed that 80% of the Cry1Ab remained in the pigs' large intestine. This shows that the Bt proteins are far more stable under real conditions than had hitherto been assumed based on the results of the digestion tests. As a result, the risks relating to the development of immune-related diseases have been incorrectly evaluated. Walsh et al. is also not the only work to have demonstrated these risks: back in 2003, Chowdhurry et al. presented similar results.

When the Starlink corn contamination case came to light in 2000, the authorities were faced with the problem that these crops produced a Bt toxin that was known not to be broken down quickly by the digestive system. In order to avoid any risk to consumers, these crops were only authorised from the outset for use in animal feed. But when they were subsequently detected in food, Industry had to launch an expensive product withdrawal operation (see above). Based on the studies by Chowdhurry et al. (2003) and Walsh et al (2012), the fear is that the Starlink risk is also relevant for Bt crops, which have been authorised for food production for many years now.

7. Impact on the environment

The environmental consequences are manifold. Many of them relate to the fact that the cultivation of herbicide-tolerant crops makes it possible to increase herbicide applications. It can also be said that the uncontrolled spread of GE crops is already well under way.

7.1 Cultivation of herbicide-resistant crops

So far, the cultivation of herbicide-tolerant crops has had a particularly dire impact on the environment. GE crops make it possible, in particular, to spray glyphosate on a wide scale across very large soybean, corn, sugar beet, rapeseed and cotton fields and have led to the emergence and spread of herbicide-resistant weeds. Genetic engineering is a driving force behind the development of agricultural production systems that are unsustainable and which have had an increasingly negative impact on the environment. This assertion is particularly important in that GE crops were initially introduced based on the argument that they would enable the amount of crop spraying to be reduced. Farmers and the environment are affected in equal measure by this phenomenon.

Since the herbicide that is sprayed on a significant proportion of the leaves spreads to the stems and, from there, filters down to the very tips of the stems in the ground (FAO, 2005, Cakmak et al., 2009), the soil life and, above all, the symbiosis between the nitrogen-fixing bacteria and the roots of the crops are disrupted, which in turn has an impact on nitrogen supply to plants (Zablotowicz & Reddy, 2007, quoted by PAN AP, 2009, see also Druille et al., 2012) and the absorption of minerals such as manganese and zinc (Cakmak et al., 2009; Johal & Huber 2009). All in all, soil fertility is decreasing as a result of increased glyphosate application and crops are becoming more susceptible to disease (Johal Huber, 2009, Bott et al., 2008). This increased exposure can cause fungal diseases. The decomposition of glyphosate in the ground can be delayed as a result of the concomitant cultivation of insecticide-producing crops (Accinelli et al., 2004) or the application of additional herbicides (Tejada, 2009, quoted by PAN AP, 2009).

EFSA also believes there is a problem in this area. In its assessment of the cultivation of NK603, EFSA states (2009a):

> *"Glyphosate can also have effects on soil microbial communities, mycorrhizal fungi and rhizobial populations important in plant nutrient cycling (…) The consequences of this could be that glyphosate applications will reduce rhizobial populations, at least temporarily, thus reducing microbial functions and contributions to field ecosystems - principally in relation to fixing nitrogen. This could lead to increases in synthetic nitrogen application with consequences for the environment, especially water run-off etc. (…) glyphosate use significantly reduces maize litter decomposition although the glyphosate effect is dependent on the location of litter placement."*

This phenomenon has also led to declining biodiversity on farmland. For example, the Monarch butterfly, an icon of nature conservation in the USA, migrates between the USA and Mexico, where the butterflies hibernate. It has been observed that the size of the butterfly population arriving in Mexico over the last 10 years has fallen significantly. One reason for this is that the presence of forage crops, which are important for the caterpillars (certain milkweed species), has declined considerably. The US scientists, Pleasants & Oberhauser (2012), who have studied this phenomenon, wrote the following:

"The size of the Mexican overwintering population of monarch butterflies has decreased over the last decade. Approximately half of these butterflies come from the U.S. Midwest where larvae feed on common milkweed. There has been a large decline in milkweed in agricultural fields in the Midwest over the last decade. This loss is coincident with the increased use of glyphosate herbicide in conjunction with increased planting of genetically modified (GM) glyphosate-tolerant corn (maize) and soybeans (soya). We investigate whether the decline in the size of the overwintering population can be attributed to a decline in monarch production owing to a loss of milkweeds in agricultural fields in the Midwest. (…) We estimate that there has been a 58% decline in milkweeds on the Midwest landscape and an 81% decline in monarch production in the Midwest from 1999 to 2010. Monarch production in the Midwest each year was positively correlated with the size of the subsequent overwintering population in Mexico. Taken together, these results strongly suggest that a loss of agricultural milkweeds is a major contributor to the decline in the monarch population."

Figure 16: Monarch butterfly (*Danaus plexippus*) (source: http://de.wikipedia.org/wiki/Monarchfalter)

It is also known that glyphosate application has particular effects on aquatic ecosystems (FAO, 2000). The use of pesticides, even in small concentrations, can have adverse effects on aquatic life. For example, long-term exposure to low concentrations in freshwater snails (*Pseudosuccinea columella*) caused reproductive problems, not among the first or second but among the third generation of offspring (increased number of deformed embryos, Tate et al., 1997, quoted by PAN AP, 2009). Studies of amphibians highlighted significant toxicity. Frog and toad tadpoles (Relaya, 2005 a and b; Relaya 2012; Relaya & Jones, 2009) are just as sensitive to the presence of glyphosate in water as frog embryos (Paganelli et al., 2010). According to information from the US EPA, glyphosate is a threat to the habitat of protected amphibians such as the red-legged frog[13]. A study by the Environment Ministry in British Colombia, Canada, reached the conclusion that the risks to amphibians posed by the application of glyphosate mixtures should be re-evaluated (Govindarajulu, 2008).

13 http://www.epa.gov/oppsrrd1/registration_review/glyphosate/index.htm www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0361-0003gov/#!documentDetail;D=EPA-HQ-OPP-2009-0361-0003

Roundup and, in particular, the additive POE tallow amine have also proved to be toxic to freshwater molluscs (Bringolf et al 2007). The level of toxicity of POE tallow amine in fish has been recorded as being 30 times higher than the level of glyphosate present in the same fish (Servizi et al., 1987, quoted by PAN AP, 2009).

A monograph by the Pesticide Action Network PAN AP (2009) summarises the threat to the aquatic system in the following terms:

> *"Glyphosate and/or Roundup can alter the composition of natural aquatic communities, potentially tipping the ecological balance and giving rise to harmful algal blooms. It can have profound impacts on microorganisms, plankton, algae and amphibia at low concentrations: one study showed a 70% reduction in tadpole species and a 40% increase in algae. Insects, crustaceans, molluscs, sea urchins, reptiles, tadpoles, and fish can all be affected, with vulnerability within each group varying dramatically between species."*

Effects have also been observed at other levels of biodiversity, such as insects, arthropods and worms (PAN AP, 2009). EFSA has also observed clear environmental effects when herbicide-resistant crops are planted on a large scale. The authority states that if cultivation were authorised in the EU, appropriate measures could be taken to prevent these repercussions, but it cannot be denied that these problems exist in countries where crops such as Monsanto Roundup Ready soybean (soybean 40-3-2) are actually grown:

> *"The EFSA GMO Panel is of the opinion that potential adverse environmental effects of the cultivation of soybean 40-3-2 are associated with the use of the complementary glyphosate-based herbicide regimes. These potential adverse environmental effects could, under certain conditions, comprise: (1) a reduction in farmland biodiversity; (2) changes in weed community diversity due to weed shifts; (3) the selection of glyphosate resistant weeds; and (4) changes in soil microbial communities." (EFSA, 2012)*

The negative effects of the cultivation of glyphosate tolerant crops actually affect rural areas as a whole, rather than only agriculture. A study conducted in Mississippi and Iowa in 2007 and 2008 showed that glyphosate was present in most of the samples of air and rainwater taken. (Chang et al., 2011). Battaglin et al. (2011) identified glyphosate in 93 percent of all soils samples analysed, 70 percent of rainwater samples, 50 percent of smaller rivers and 20 percent of the lakes.

A number of studies have established a link between glyphosate application and illnesses developed by farmers (PAN, 2009). Laboratory tests on amphibians and avian embryos led Paganelli et al. (2010) to warn of the human health risks of this phenomenon.

US experts, such as Benbrook (2012a) and Mortensen (2012), warn that the environmental problem in rural areas could get significantly worse if herbicide-resistant crops, such as 2,4 D or Dicamba, are planted.

7.2 Cultivation of insecticide-producing crops

Never before anywhere on earth have such large-scale insecticide-producing monocrops been grown. Even if the naturally occurring Bt toxin is regarded as significantly more environmentally friendly than the conventional insecticide, then the well-known principle that states that it is the dose that makes the poison certainly applies.

In reality, the toxin levels in the fields are also significantly increased as a result of the presence of crops such as SmartStax. The toxin levels produced by the crops are many times higher than those released into the fields, for example, by crops such as MON810 (which only produce one insecticide). Whereas the leaves of crops such as MON810 normally contain Bt levels of around 30 µg/g (dry weight, dw) (see Lorch, A. & Then, C., 2007, EFSA, 2009b), the levels in SmartStax are likely to be 270-1600 µg/g (dry weight) (Testbiotech, 2011). Benbrook (2012a) estimates that MON810 causes the release of around 0.133 kg/hectare of Bt toxins into the fields compared with over 4 kg for Smartstax.

The impact on the ecosystem, both below and above ground, as a result of such long-term exposure to the toxin cannot be neutral. There have been discussions about the effects on the caterpillars of protected butterflies, which are known to be sensitive to the insecticide produced by the crops. However, the consequences for other non-target organisms, such as soil life, aquatic organisms, predator insects and honeybees, are disputed (Lövei et al., 2009; Lang & Otto, 2010).

Pending risk-related issues include certain traits of corn crops, such as their Bt content, which can fluctuate greatly depending on environmental influences (Then & Lorch, 2008). When assessing the toxicity of the Bt toxins, consideration needs to be given to the fact that their structure is significantly different from their naturally occurring variants. As a result, their toxicity can be much higher and their spectrum of activity much broader (Hilbeck & Schmid, 2006; Then, 2010b). In addition, the exact activity of the toxins has not yet been fully explained (Pigott & Ellar, 2007). The strict selectivity of Bt toxins has not yet been empirically analysed in depth, but instead derived from a partially outdated activity theory. Negative effects of the Bt toxins were, in any case, also observed in organisms that do not belong to the group of butterfly larvae. More recent research results show that Bt toxins are active in different ways (Soberon et al., 2009) and possibly also harbour risks for mammals. Hilbeck et al. (2012) show that strict Bt toxin selectivity in relation to non-target organisms cannot be expected. Mesnage et al. (2012) were able to demonstrate that at least a few Bt toxins used in GE crops can have adverse effects on human cells.

Interactions between the Bt toxins and/or other substances, such as pollutants, bacteria, plant enzymes or pesticides, can cause an increase in the potency of the toxins and a lower level of selectivity (Then, 2010b). Such effects can have impacts on the ecosystem and on human and animal health. EFSA (2009b) also acknowledged that possible combinatory effects in relation to honeybees, for example, entailed risks.

7.3 Uncontrolled spread of transgenic organisms in the environment

Several regions of the world have already experienced the uncontrolled spread and irreversible release of GE crops.

In the United States, there have, in particular, been reported cases of the uncontrolled spread of rapeseed. Field tests conducted by researchers at the University of Arkansas showed that GE rapeseed had spread well beyond the confines of the fields (Schafer et al., 2011). Rapeseed (species *Brassica napus*) then hybridises with closely related species (*Brassica rapa*) and is crossed with other GE rapeseed crops with the result that, outside the fields, new, untested gene combinations (stacked events) are created containing several DNA constructs.

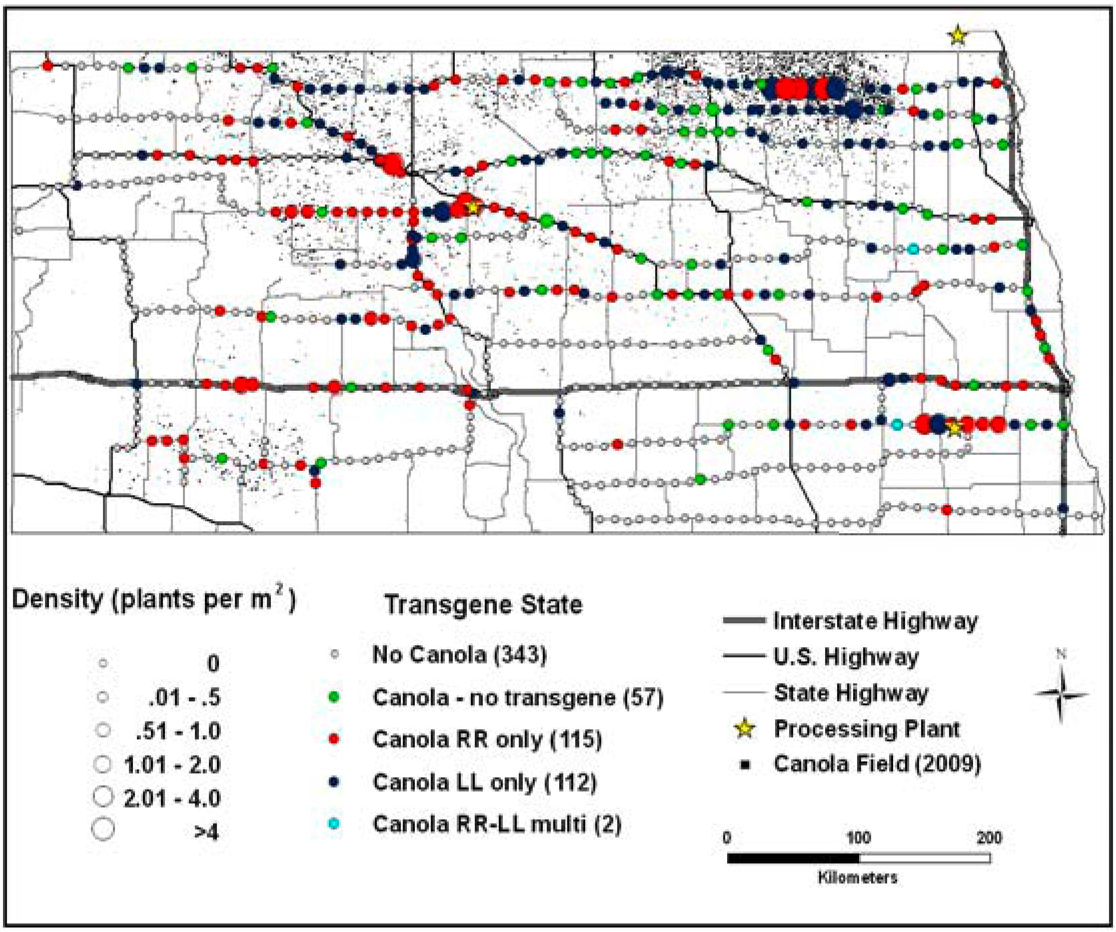

Figure17: Spread of GE rapeseed along the Highways in North Dakota, US. Studies detected transgenic rapeseed crops that were tolerant to glyphosate (RR) and/or glufosinate (LL), including crops with DNA combinations that were not authorised for sale (source: Schafer et al., 2011).

Rapeseed has a particular propensity to spread uncontrollably. Rapeseed seed (the grains are also harvested for oil production) can remain in the ground for around 10 years (seed dormancy) without

losing its germination capacity. The pollen from the crops can be spread kilometres wide by the wind. Rapeseed can survive over winter in the Northern Hemisphere, grow outside the boundaries of arable land and spread along transport routes, such as railway lines or access roads to oil mills when grains fall from their container during transport.

Some experts believe that GE herbicide-tolerant rapeseed will only establish itself permanently in the environment if it continues to be exposed to the pesticides to which it was made resistant. However, Warwick et al. (2008) have demonstrated that GE herbicide-tolerant rapeseed can establish itself in the environment for many years even when the herbicides are no longer there to act as a selection pressure. Moreover, hybridisation with related species can also cause unexpected heterosis effects, which lead to increased seed formation, for example.

It is difficult to predict the real extent of the damage caused by the spread of crops in the environment. A possible estimate could be made based on a comparison with new species (neophytes) present in the environment. There are many documented cases of species that have spread within the ecosystem over the last few years without ever causing any noticeable damage. Only a small percentage of these species can actually survive permanently. However, some species do survive, spread and cause tangible – and sometimes significant - environmental damage[14].

Unlike the neophytes, GE crops contain a technical DNA construct that is not subject to the natural regulation of gene expression in the plant cells. Under the influence of climate change or in their interaction with other stress factors, this can cause unexpected effects in the crops that imply completely new risks for the environment.

What, therefore, are the risks presented by GE crops, given that they cannot be prevented from spreading uncontrollably in time and in space? Any risk assessment must take account of evolutionary dimensions. According to Breckling[15], the following are examples of combinations that should be taken into account:

" - Evolutionary dynamics combine large numbers on the population level and singularities on the molecular scale;

- Even combinations with extremely low probability have a reasonable chance to occur;

- Depending on the particular environmental conditions organismal reproduction enables selfamplification across several orders of magnitude and large scale dispersal and cannot be predicted;

- Genetic drift can cause the fixation of genes on pure random basis particularly in small populations;

- The fitness of new genomic constituents cannot be calculated in absolute terms. It depends on the environment and its future changes."

In light of these dimensions, it cannot be denied that a long-term experiment has started in the United States, which human beings lost control of a long time ago.

14 Many of these cases are documented at: http://www.europe-aliens.org/

15 GMLS Conference in Bremen, 2012, http://www.gmls.eu/

8. Consequences for Europe

Europe and especially the EU took a different path to the United States as regards the introduction of GE crops. Although the technology in Europe and the United States has developed in parallel, Europe has been far more cautious in introducing such products on the market, both as regards crop cultivation and food labelling. However, seed patenting has developed at a similar pace in Europe and the United States.

8.1 Genetically engineered crop cultivation

Genetically engineered rapeseed that has been made resistant to the herbicide glufosinate and which is spreading across the United States and Canada in an uncontrolled manner was originally developed by a European company (Plant Genetic Systems). The company then took its products to the United States in order to avoid the legal restrictions in force in the EU. Up to now, the commercial cultivation of GE rapeseed is not permitted in the EU. An uncontrolled spread of this crop in the EU has not yet been reported – though such an occurrence cannot be ruled out. Experimental cultivation of this crop has been performed in the EU – in these fields, uncontrolled germination of rapeseed seed that has survived in the soil could occur. GE rapeseed may also be imported into the EU for processing and can enter the environment during transportation. It is questionable whether the EU might want to authorise, in the near future, the import of more GE rapeseed (Ms8 x Rf3) produced by Bayer.

Currently only MON810, an insecticide-producing corn, is grown in the EU on around 100,000 hectares of farmland – most of which is in Spain. If the amount of farmland devoted to this crop cultivation were to be expanded, experience not only in the United States but also in South Africa, China and India suggests that new insect pests would spread or would become resistant to the Bt toxin (Then, 2010a). As a result, it would be merely a question of time before triple stacks, such as SmartStax, which produce several insecticides at a time, started to be cultivated in Europe, too. Everything points such a development in the Bt-crop sector being unavoidable.

Moreover, the EU may soon see herbicide-resistant soybean and corn being grown by Monsanto in Europe – EFSA has already completed its safety assessment (EFSA, 2009; EFSA, 2012). This would jeopardise the EU's sustainable farming approach and pave the way for increasing industrialisation of agriculture, the expansion of monocrops and increasing pesticide use, as has been witnessed already in the United States. Benbrook (2012 b) also warns, against this backdrop, of a significant increase in pesticide application in the EU.

8.2 Import of products made from genetically engineered crops

The EU has established a labelling system for products made from genetically engineered organisms. This has made it possible to differentiate between products and create stability on the markets – such products have so far only been of marginal relevance in terms of food production in Europe. Consumer interests have to a large extent taken precedence in this area. However, huge costs have been incurred in the EU as a result of contamination from GE crops. The cost of monitoring these products and, where necessary, the cost of product recall operations is borne by those producers who want to produce non-GE products (Then & Stolze, 2010).

Moreover, millions of tonnes of animal feed are imported each year (including 40 million tonnes of soybean alone), without there being any requirement to label these animal products. There are very few meat, dairy and egg products on the market that come from animals that have not been fed with feed made from herbicide-tolerant or insecticide-producing crop grains. In recent years, mainly soybean was imported, whereas nowadays the demand for corn is increasing too. It is expected that the EU will import up to 10 million tonnes of corn by 2012[16], almost double the amount imported in 2011 and the largest imported quantities to date. The reason for this is the crop failures in eastern Europe.

The increasing import volumes are placing the EU's authorisation bodies under increasing pressure. The international animal feed sector is pressing for an opening of the markets and authorisation decisions for the EU and US markets to be made concurrently. There is therefore a danger that the risk assessments will be influenced by economic interests, which is borne out by a number of examples: a call made by the animal feed industry at the FEFAC Congress in June 2011 for the EU to authorise the import of the GE insecticide-producing corn MIR162 was swiftly heeded in October 2012, thus paving the way for further corn imports from the United States and Brazil. MIR162 contains an insecticide (Vip3Aa20) that belongs to a new category of Bt insecticides. The exact mode of action of this toxin is not known and, therefore, the prerequisite needed to be able to perform an adequate risk assessment is missing (Testbiotech, 2012). Moreover, a comprehensive risk assessment has not been conducted, which clearly shows the power of the animal feed industry.

This case shows the bearing that the EU has on GE crop cultivation in other parts of the world. Cultivation is often started only once the EU has issued an import authorisation. When applying in Brazil to cultivate its soybean 87701x89788 (which is both herbicide-tolerant and insecticide-producing), Monsanto made sure that the conditions of cultivation would meet the EU's strict authorisation requirements[17].

A total of 47 events are now authorised in the EU for use in feed and food. These crops produce a total of 11 different insecticides and are resistant to several herbicides. Interactions affecting these crops and the effects of consuming these crops following their market authorisation have never been studied, even though monitoring is a compulsory requirement under EU law. The actual residue levels from crop-spraying are not examined in the risk assessment and imports of these products are not monitored systematically (Then, 2011).

16 http://www.reuters.com/article/2012/10/16/europe-maize-imports-idAFL5E8LCNGU20121016

17 http://www.europabio.org/sites/default/files/fact-sheet_for_mon_87701_x_mon_89788_soybean.pdf

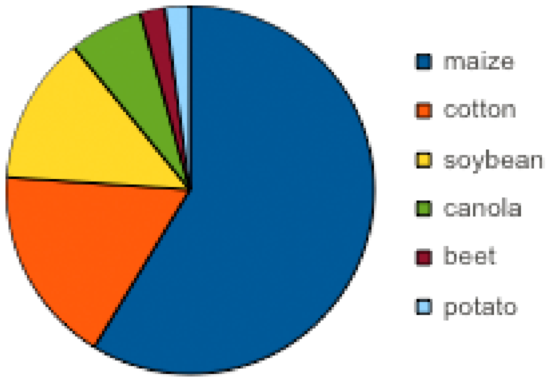

Figure 18: EU authorisations of genetically engineered crops, categorised in species, December 2012 (http://ec.europa.eu/food/dyna/GE_register/index_en.cfm)

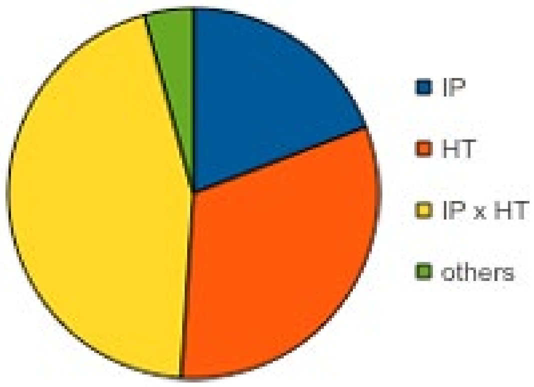

Figure 19: EU authorisations of genetically engineered events, categorised in traits December 2012. IP: insecticide-producing crops, HT: herbicide-tolerant crops, IPxHT: combination of traits (stacked events). Other: 1 x starch production ('Amflora' potato), 1 x pollen sterility. (http://ec.europa.eu/food/dyna/gm_register/index_en.cfm)

8.3 Seed patenting

The continuing concentration in the seed sector is also affecting the EU. There is still a comparatively broad range of seed companies, but companies such as Pioneer and Dekalb, which are owned by DuPont and Monsanto, respectively, also have a large share of the corn seed market in Europe.

A report that several Swiss organisations were commissioned to produce[18] also paints an alarming picture of the situation in the EU vegetable seed sector. According to the report, Monsanto owns 36% of the tomato seed varieties registered with the Plant Variety Office, as well as 32% of the chilli varieties and 49% of the cauliflower varieties. These market shares have been made possible by buying up vegetable breeder companies such as Seminis and DeRuiter.

In Europe, increasing numbers of patent applications are also being filed. Over 2,000 patents have already been granted for seeds – most of which have been genetically engineered. However, the share

18 http://www.evb.ch/cm_data/Saatgutmarkt_Juni_2012.pdf

of patent applications for conventional seeds has also been increasing for many years now (Then & Tippe, 2012). If this development is not stopped, there is a risk, in the medium term, of levels of dependency similar to those in the United States. If GE seed were to be grown in the EU on a similar scale to the USA, the seed market would be structured along similar lines to the US market – i.e. all GE crops whose seeds are sold commercially have been patented.

9. Recommendations

In light of the effects caused so far as a result of GE crop cultivation in the United States, the following recommendations can be made:

1. There must be no large-scale, commercial cultivation of GE herbicide-tolerant or insecticide-producing crops. Such crop cultivation is unsustainable and will lead to a 'race' to step up their cultivation.
2. Ensure that all potential situations are retrievable: cultivation of crops such as rapeseed, which is extremely susceptible to spread through the environment, should be banned as a matter of principle. An absolute prerequisite for any release of such crops is that it must be possible to control their spread and their persistence in the environment.
3. Prevent cases of contamination: A particular focus on clean seed is needed because otherwise farmers will lose control over the cultivation of GE crops in their fields and it will no longer be possible to adequately differentiate between products in the subsequent stages of the food production chain.
4. Risk assessments and risk research should not be geared to economic interests. Under EU law, environmental and consumer protection clearly take precedence over other interests. This must be applied more rigidly in practice. Directives based on EFSA risk assessments must be tightened up significantly and the preconditions for independent risk research must be specifically fostered.
5. The health effects of consuming products made from GE crops must be monitored. Under EU law, the monitoring of the impact on public health and the environment of products authorised for marketing in the EU is compulsory, but has only been partially implemented.
6. To allow for the differentiation of products on the feed markets, labelling should be extended to include animal products. The EU should also focus specifically on the search for alternatives to existing feed production and import markets.
7. To prevent further concentration on seed markets, seed patenting must be stopped.
8. A plan for research into alternatives must be mapped out: in many areas conventional breeding is a cheaper, more productive and safer alternative for the production of new seed varieties. This approach should be specifically fostered in the future.

References

AAPCO (1999 & 2005) 1999/2005 Pesticide Drift Enforcement Survey. Association of American Pesticide Control Officials, at http://aapco.ceris.purdue.edu/htm/survey.htm. Survey periods 1996-1998 and 2002-2004, respectively

Accinelli C, Screpanti C, Vicari A, Catizone P. (2004) Influence of insecticidal toxins from *Bacillus thuringiensis* subsp. kurstaki on the degradation of glyphosate and glufosinate-ammonium in soil samples. Agric Ecosys Environ 103:497-507

Adel-Patient, K., Guimaraes, V., Paris, A., Drumare, M., Ah-Leung, S., Lamourette, P., Nevers, M., Canlet, C., Molina, J., Bernard, H., Creminon, C., Wal, J. (2011) Immunological and metabolomic impacts of administration of Cry1Ab protein and MON 810 maize in mouse, Plos One, 6

Aris, A & LeBlanc, S (2011) Maternal and fetal exposure to pesticides associated to genetically modified foods in Eastern Townships of Quebec, Canada. Reproductive Toxicology, 31(4):528-33.

Battaglin, W. A.; Meyer, M. T.; Dietze, J. E. (2011) Widespread Occurrence of Glyphosate and its Degradation Product (AMPA) in U.S. Soils, Surface Water, Groundwater, and Precipitation, 2001-2009. American Geophysical Union, Fall Meeting 2011. http://adsabs.harvard.edu/abs/2011AGUFM.H44A..08B

Benbrook, C.M. (2012a), Impacts of genetically engineered crops on pesticide use in the U.S. -- the first sixteen years Environmental Sciences Europe 2012, 24:24 doi:10.1186/2190-4715-24-24

Benbrook, C.M. (2012b), Glyphosat tolerant crops im the EU, a forecast of impacts on herbicide use, perpared for Greenpeace international, http://www.greenpeace.org/international/Global/international/publications/agriculture/2012/GI_Herb_Use_FINAL_10-18-12.pdf

Bundesinstitut für Risikobewertung, BfR (2012) Veröffentlichung von Seralini et al. zu einer Fütterungsstudie an Ratten mit gentechnisch verändertem Mais NK603 sowie einer glyphosathaltigen Formulierung, Stellungnahme Nr. 037/2012 des BfR vom 28. September 2012, http://www.bfr.bund.de/cm/343/veroeffentlichung-von-seralini-et-al-zu-einer-fuetterungsstudie-an-ratten-mit-gentechnischveraendertem-mais-nk603-sowie-einer-glyphosathaltigen-formulierung.pdf

Binimelis, R., Hilbeck, A., Lebrecht T., Vogel R., Heinemann J. (2012) Farmer's choice of seeds in five regions under different levels of seed market concentration and GM crop adoption, GMLS Conference 2012, http://www.gmls.eu/

Bonny, S. (2011) Herbicide-tolerant transgenic soy-bean over 15 years of cultivation: Pesticide use, weed resistance and some economic issues. The case of the USA. Sustainability, 3: 1302–1322.

Bott, S., Tesfamariam, T., Candan, H., Ismail Cakmak, I., Römheld, V., Neumann, G. (2008) Glyphosate-induced impairment of plant growth and micronutrient status in glyphosate-resistant soybean (Glycine max L.), Plant Soil 312:185–194.

Bringolf R.B., Cope W.G., Mosher S., Barnhart M.C., Shea D. (2007) Acute and chronic toxicity of glyphosate compounds to glochidia and juveniles of Lampsilis siliquoidea (Unionidae). Environ Toxicol Chem 26(10):2094-100.

Brookes G. & Barfoot P. (2012) The income and production effects of biotech crops globally 1996–2010 GM Crops and Food: Biotechnology in Agriculture and the Food Chain 3:4, 265-272

Brookes, G. & Barfoot, P. (2008) Global Impact of Biotech Crops: Socio-Economic and Environmental Effects, 1996-2006. In: AgBioForum, Jg. 11, H. 1, S. 21–38.

Cakmak I., Yazici A., Tutus Y., Ozturk L. (2009) Glyphosate reduced seed and leaf concentrations of calcium, manganese, magnesium, and iron in non-glyphosate resistant soybean. Eur J Agron 31(3):114-9.

Carlisle S.M. & Trevors, J.T. (1988) Glyphosate in the environment, Water, Air and Soil Pollution 39, 409-420

Carter, C. A. & Smith, A. (2003) StarLink Contamination and Impact on Corn Prices. Contributed paper presented at the International Conference Agricultural policy reform and the WTO: where are we heading? Capri (Italy), June 23-26, 2003.
http://www.ecostat.unical.it/2003agtradeconf/Contributed%20papers/Carter%20and%20Smith.pdf

Catangui, M.A. & Berg, R.K. (2006) Western bean cutworm, *Striacosta albicosta* (Smith) (*Lepidoptera: Noctuidae*), as a potential pest of transgenic Cry1Ab *Bacillus thuringiensis* corn hybrids in South Dakota, Environmental Entomology 35: 1439–1452

Chainark, P. (2008) Availability of genetically modified feed ingredient II: investigations of ingested foreign DNA in rainbow trout Oncorhynchus mykiss. Fisheries Science, 74(2):380-390.

Chang F.-C., Simcik M.F., Capel P.D. (2011) Occurrence and fate of the herbicide glyphosate and its degradate aminomethylphosphonic acid in the atmosphere. Environ Tox and Chem 2011, 30:548–555. doi:10:1002/35c.431.

Chowdhury, E. H., Kuribara, H., Hino, A., Sultana, P., Mikami, O., Shimada, N., Guruge, K.S., Saito M., Nakajima Y., (2003) Detection of corn intrinsic and recombinant DNA fragments and Cry1Ab protein in the gastrointestinal contents of pigs fed genetically modified corn Bt11, J ANIM SCI 2003, 81:2546-2551

Center for Food Safety, (2005), Monsanto vrs US Farmers, www.centerforfoodsafety.org

Dorhout, D.L., Rice, M.E. (2004) First report of western bean cutworm, Richia albicosta (Noctuidae) in Illinois and Missouri. Crop Management. http://www.plantmanagementnetwork.org/pub/cm/brief/2004/cutworm

Druille, M., Cabello, M.N., Omacini, M., Golluscio, R.A. (2013) Glyphosate reduces spore viability and root colonization of arbuscular mycorrhizal fungi. Applied Soil Ecology, 64: 99–103.
http://dx.doi.org/10.1016/j.apsoil.2012.10.007

Edgerton et al. (2012) Transgenic insect resistance traits increase corn yield and yield stabilityNature biotechnology, 30: page 493-496

EFSA (2009a) Scientific Opinion of the Panel on Genetically Modified Organisms on applications (EFSA-GMO-NL-2005-22 and EFSA-GMO-RX-NK603) for the placing on the market of the genetically modified glyphosate tolerant maize NK603 for cultivation, food and feed uses and import and processing, and for renewal of the authorisation of maize NK603 as existing product. The EFSA Journal (2009) 1137, 1-50.

EFSA, (2009b), Scientific Opinion of the Panel on Genetically Modified Organisms on applications (EFSA-GMO- RX-MON810) for the renewal of authorisation for the continued marketing of (1) existing food and food ingredients produced from genetically modified insect resistant maize MON810; (2) feed consisting of and/or containing maize MON810, including the use of seed for cultivation; and of (3) food and feed additives, and feed materials produced from maize MON810, all under Regulation (EC) No 1829/2003 from Monsanto. The EFSA Journal (2009) 1149: 1–84, http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902628240.htm

EFSA (2011) Letter to DG Sanco, 19. August 2011, Ref PB/HF/AFD/mt (2011) 5863329 Request for advice from DG Sanco to analyse the articles on residues associated with GMO/ maternal and fetal exposure in relation to a previous statement from 2007 ..."

EFSA (2012) Scientific Opinion on an application (EFSA-GMO-NL-2005-24) for the placing on the market of the herbicide tolerant genetically modified soybean 40-3-2 for cultivation under Regulation (EC) No 1829/2003 from Monsanto www.efsa.europa.eu/efsajournal

Eichenseer, H., Strohbehn, R., Burks, J. (2008) Frequency and Severity of Western Bean Cutworm (Lepidoptera: Noctuidae) Ear Damage in Transgenic Corn Hybrids Expressing Different *Bacillus thuringiensis* Cry Toxins, Journal of Economic Entomology, Volume 101, 2: 555-563

ETC Group (2011) Who will control the Green Economy?, http://www.etcgroup.org/content/who-will-control-green-economy-0

European Communities (2005) Measures affecting the approval and marketing of biotech products (DS291, DS292, DS293). Comments by the European Communities on the scientific and technical advice to the panel, http://trade.ec.europa.eu/doclib/docs/2004/june/tradoc_117687.pdf

FAO (2000) FAO Specifications and Evaluations for Plant Protection Products: Glyphosate N-(phosphonomethyl)glycine. Food and Agriculture Organization of the United Nations, Rome.

FAO (2005) Pesticide Residues in Food, FAO Plant Production and Protection Paper 183, http://www.fao.org/docrep/009/a0209e/a0209e00.htm

Forlani, G., Kafarski P., Lejczak B., Wieczorek P. (1997) Mode of Action of Herbicidal Derivatives of Aminomethylenebisphosphonic Acid. Part II. Reversal of Herbicidal Action by Aromatic Amino Acids J Plant Growth Regul (1997) 16:147–152

Finamore, A., Roselli, M., Britti, S., Monastra, G., Ambra, R., Turrini, A. & Mengheri, E. (2008) Intestinal and peripheral immune response to MON810 maize ingestion in weaning and old mice. Journal of Agricultural and Food Chemistry 56: 11533–11539

GAO, United States Government Accountability Office (2008) Genetically Engineered Crops. Agencies Are Proposing Changes to Improve Oversight, but Could Take Additional Steps to Enhance Coordination and Monitoring. Report to the Committee on Agriculture, Nutrition, and Forestry U.S. Senate, http://www.gao.gov/new.items/d0960.pdf

Gassmann A.J., Petzold-Maxwell J.L., Keweshan R.S., Dunbar M.W. (2011) Field evolved resistance to Bt maize by Western corn rootworm. PLoS ONE 6, e22629.

Gensior A., Roth G., Well R., (2012): Landwirtschaftliche Bodennutzung. In Bodenschutz 3/12

Govindarajulu, P.P. (2008) Literature review of impacts of glyphosate herbicide on amphibians: What risks can the silvicultural use of this herbicide pose for amphibians in B.C.?, Province of British Columbia, Ministry of Environment, Canada http://stopthespraybc.com/wp-content/uploads/2011/07/Literature-Review-of-Impacts-of-Glyphosate-Herbicide1.pdf

Gray, M. (2011) Severe root damage to Bt corn observed in northwestern Illinois. The Bulletin, No. 20, August 26, 2011 http://bulletin.ipm.illinois.edu/article.php?id=1555

Grube, A., Donaldson, D., Kiely, T., Wu, L, (2011), Pesticides industry sales and usage. 2006 and 2007 market estimates. EPA, Washington, D.C., http://www.epa.gov/opp00001/pestsales/07pestsales/market_estimates2007.pdf

Hilbeck, A. & Schmidt, J.E.U. (2006) Another view on Bt proteins – How specific are they and what else might they do?: Biopesticides International 2(1): 1–50

Hilbeck, A., McMillan, J.M., Meier, M., Humbel, A., Schlaepfer-Miller, J., Trtikova, M. (2012) A controversy re-visited: Is the coccinellia Adalia bipunctata adversely affected by Bt toxins, Environmental Sciences Europe 24(10), doi:10.1186/2190-4715-24-10.

Höper H. & Schäfer W. (2012) Die Bedeutung der organischen Substanz von Mineralböden für den Klimaschutz. In Bodenschutz 3/12

Howard, P.H. (2009). Visualizing Consolidation in the Global Seed Industry: 1996–2008, Sustainability 2009, 1, 1266-1287; doi:10.3390/su1041266

Hubbard, K. (2009) Out of Hand, Farmers Face the Consequences of a Consolidated Seed Industry, National Family Farm Coalition, http://farmertofarmercampaign.com

Hutchison W.D., Hunt, T.E., Hein, G.L., Steffey, K.L., Pilcher C.D., Rice, M. E., (2011), Genetically Engineered Bt Corn and Range Expansion of the Western Bean Cutworm (Lepidoptera: Noctuidae) in the United States: A Response to Greenpeace Germany, J. Integ. Pest Mngmt. 2(3): 2011; DOI: http://dx.doi.org/10.1603/IPM11016

Johal G.S,, Huber D.M. (2009) Glyphosate effects on diseases of plants. Eur J Agron 31(3):144-52.

Kleter, G.A., Unsworth, J.B., Harris, C.A. (2011) The impact of altered herbicide residues in transgenic herbicide-resistant crops on standard setting for herbicide residues, Pest Management Science 67, 10: 1193–1210. DOI 10.1002/ps.2128

Kroghsbo, S., Madsen, C., Poulsen, M., Schrøder, M., Kvist, P.H., Taylor, M., Gatehouse, A., Shu, Q., Knudsen, I. (2008) Immunotoxicological studies of genetically modified rice expressing PHA-E lectin or Bt toxin in Wistar rats. Toxicology. 245, 24-34

Lang , A., & Otto, M. (2010) A synthesis of laboratory and field studies on the effects of transgenic *Bacillus thuringiensis* (Bt) maize on non-target Lepidoptera , Entomologia Experimentalis et Applicata 135: 121–134, 2010

Lövei, G. L., Andow D.A., Arpaia, S. (2009) Transgenic insecticidal crops and natural enemies: a detailed review of laboratory studies. Environmental Entomology 38(2): 293-306

Lorch, A. & Then, C. (2007) How much Bt toxin do GE MON810 maize plants actually produce, Greenpeace-Report, www.greenpeace.de/fileadmin/gpd/user_upload/themen/gentechnik/greenpeace_bt_maize_engl.pdf

Macilwain, C. (2005) US launches probe into sales of unapproved transgenic corn. In:

Nature, Jg. 434, H. 7032, S. 423

Mazza, R., Soave1, M., Morlacchini, M., Piva, G., Marocco, A. (2005) Assessing the transfer of genetically modified DNA from feed to animal tissues. Transgenic Res. 14: 775-784.

Mesnage R., Clair E., Gress S., Then C., Székács A., Séralini G.-E. (2012) Cytotoxicity on human cells of Cry1Ab and Cry1Ac Bt insecticidal toxins alone or with a glyphosate-based herbicide, Journal of Applied Toxicology, http://onlinelibrary.wiley.com/doi/10.1002/jat.2712/abstract

Michel, A.P., Krupke C.H., Baute, T.S., Difonzo C.D. (2010) Ecology and Management of the Western Bean Cutworm (Lepidoptera: Noctuidae) in Corn and Dry Beans, J. Integ. Pest Mngmt. 1(1): 2010; DOI: 10.1603/IPM10003

Monsanto (2010) Request for Extension of Determination of Nonregulated Status to the Additional Regulated Article: Roundup Ready Corn Line NK603, http://www.aphis.usda.gov/brs/aphisdocs/00_01101p.pdf

Monsanto (2011) Annual monitoring report on the cultivation of MON 810 in 2010, http://ec.europa.eu/food/food/biotechnology/docs/report_mon_810_en.pdf

Mortensen D.A., Egan J.T., Maxwell B.D., Ryan M.R., Smith R.G. (2012) Navigating a critical juncture for sustainable weed management. BioScience 2012, 62:75–84

OECD (1992) Biotechnology, Agriculture and Food, 1992, Published by OECD Publishing, Publication, 28 July 1992, OECD Code: 931992031P1, ISBN 92-64-13725-4

O'Rourke, P. K., Hutchinson, W. D., (2000) First report of the western bean cutworm, Richia albicosta (Smith) (Lepidoptera: Noctuidae), in Minnesota corn. J. Agric. Urban. Entomol. 17: 213-217.

Oswald, K. J., French, B.W., Nielson, C., Bagley, M. (2012) Assessment of fitness costs in Cry3Bb1-resistant and susceptible western corn rootworm (Coleoptera: Chrysomelidae) laboratory colonies. Journal of Applied Entomology, DOI: 10.1111/j.1439-0418.2012.01704.x

Paganelli, A., Gnazzo, V., Acosta, H., Lopez, S.L., Carrasco, A.E. (2010) Glyphosate-based herbicides produce teratogenic effects on vertebrates by impairing retinoic acid signalling. Chem. Res. Toxicol., August 9. pubs.acs.org/doi/abs/10.1021/tx1001749

PAN AP, Pesticide Action Network Asian Pacific (2009) Monograph on Glyphosate, www.panap.net/en/p/post/pesticidesinfo-database/115

Pigott, C.R. & Ellar, D.J. (2007) Role of Receptors in *Bacillus thuringiensis* Crystal Toxin Activity: Microbiol Mol Biol Rev 71 (2): 255–281

Pleasants, J.M & Oberhauser K.S. (2012) Milkweed loss in agricultural fields due to herbicide use: Effect on the Monarch Butterfly population. Insect Conservation and Diversity, DOI: 10.1111/j.1752-4598.2012.00196.x

Ran, T., Mei, L., Lei, W., Aihua, L., Ru, H., Jie, S. (2009) Detection of transgenic DNA in tilapias (Oreochromis niloticus, GIFT strain) fed genetically modified soybeans (Roundup Ready), Aquaculture Research, 40 (12): 1350-1357.

Relyea R.A. (2005a). The lethal impact of Roundup on aquatic and terrestrial amphibians. Ecol Applic 15(4):1118-24.

Relyea R.A. (2005b) The lethal impacts of Roundup and predatory stress on six species of North American tadpoles. Arch Environ Contam Toxicol 48:351-7.

Relyea, R.A. (2012) New effects of Roundup on amphibians: Predators reduce herbicide mortality; herbicides induce antipredator morphology. Ecological Applications 22: 634-647. http://dx.doi.org/10.1890/11-0189

Relyea R.A. & Jones D.K. (2009) The toxicity of Roundup Original Max to 13 species of larval amphibians. Environ Toxicol Chem 28(9):2004-8.

Reuter, T., Alexander T.W., Martinez. T.F:, McAllister T.A. (2007) The effect of glyphosate on digestion and horizontal gene transfer during in vitro ruminal fermentation of genetically modified canola, J Sci Food Agri 87:2837-2843

Rice, M. E., (2000) Western bean cutworm hits northwest Iowa. Integrated Crop Manage. IC-484, 22, 163, Iowa State University Extension, Ames, IA.

Saeglitz, C., Bartsch, D., Eber, A., Gathmann, K., Priesnitz, K.U., Schuphan, I. (2006) Monitoring the Cry1Ab Susceptibility of European Corn Borer in Germany, J. Econ. Entomol., 99(5): 1768-1773.

Sagstad, A., Sanden, M., Haugland, O, Hansen A.C., Olsvik P.A., Hemre G.I. (2007) Evaluation of stress- and immune-response biomarkers in Atlantic salmon, Salmo salar L., fed different levels of genetically modified maize (Bt maize), compared with ist near-isogenic parental line and a commercial suprex maize, Journal of Fish Diseases, 30: 201–212

Schafer, M.G., Ross, A.A., Londo, J.P., Burdick, C.A., Lee, E.H., et al. (2011) The Establishment of Genetically Engineered Canola Populations in the U.S.. PLoS ONE 6(10): e25736. doi:10.1371/journal.pone.0025736 http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0025736

Schnepf, E., Crickmore, N., van Rie, J., Lereclus, D., Baum, J., Feitelson, J., Zeigler, D.R. & Dean, D.H. (1998) *Bacillus thuringiensis* and its pesticidal crystal proteins, Microbiol Mol Biol Rev. 62 (3): 775–806

Seralini, G-E., E. Clair, R. Mesnage, S. Gress, N. Defarge, M. Malatesta, D. Hennequin, J. Spiroux de Vendomois (2012) Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize, Food Chem. Toxicol., http://dx.doi.org/10.1016/j.fct.2012.08.005

Servizi J., Gordon R., Martens D. (1987) Acute toxicity of Garlon 4 and Roundup herbicides to salmon, Daphnia and trout. Bull Environ Contamin Toxicol 39:15-22.

Sharma, R., Damgaard, D., Alexander, T.W., Dugan, M.E.R., Aalhus, J.L., Stanford, K., McAllister, T.A. (2006) Detection of transgenic and endogenous plant DNA in tissues of sheep and pigs fed Roundup Ready canola meal. Journal of Agricultural Food Chemistry, 54: 1699–1709

Shehata A.A., Schrödl, W., Aldin A., A., Hafez H.M., Krüger M. (2012) The Effect of Glyphosate on Potential Pathogens and Beneficial Members of Poultry Microbiota In Vitro, Curr Microbiol DOI 10.1007/s00284-012-0277-2

Soberón, A., Gill, S.S., Bravo, A. (2009) Signaling versus punching hole: How do Bacillus *thuringiensis* toxins kill insect midgut cells? Cell. Mol. Life Sci. 66: 1337-1349.

Székács, A., Weiss G., Quist, D., Takács, E., Darvas, B., Meier, M., Swain T., Hilbeck A. (2011) Interlaboratory comparison of Cry1Ab toxin quantification in MON 810 maize by ezyme-immunoassay, Food and Agricultural Immunology, DOI:10.1080/09540105.2011.604773.

Tate T.M., Spurlock J.O., Christian F.A. (1997) Effect of glyphosate on the development of Pseudosuccinea columella snails. Arch Environ Contam Toxicol 33:286-9.

Tejada M. (2009) Evolution of soil biological properties after addition of glyphosate, diflufenican and glyphosate+diflufenican herbicides. Chemosphere 76:365-73.

TESTBIOTECH (2011) Expression of Bt toxins in ‚SmartStax', Analyses of Stilwell & Silvanovich, 2007 and Phillips, 2008 Report number MSL0021070 and Sub-Report ID: 61026.05

TESTBIOTECH (2012) Technical background for a complaint under Article 10 of Regulation (EC) No. 1367/2006 against decision of EU Commission to give market authorisation to stacked soy MON87701 x MON89788, http://www.testbiotech.de/node/691

Then, C., (2010a), New pest in crop caused by large scale cultivation of Bt corn, in: Breckling, B. & Verhoeven, R. (2010) Implications of GM-Crop Cultivation at Large Spatial Scales, Theorie in der Ökologie, Frankfurt, Peter Lang.

Then, C., (2010b), Risk assessment of toxins derived from *Bacillus thuringiensis*-synergism, efficacy, and selectivity. Environ Sci Pollut Res Int; 17(3):791-7

Then, C. (2011) Vorsicht "Giftmischer": Gentechnisch veränderte Pflanzen in Futter-und Lebensmitteln, ein Testbiotech-Report. http://www.testbiotech.de/sites/default/files/Testbiotech_Giftmischer_April_2011.pdf

Then, C. & Lorch, A. (2008) A simple question in a complex environment: How much Bt toxin do genetically engineered MON810 maize plants actually produce?, in: Breckling, B., Reuter, H. &Verhoeven, R. (eds), 2008, Implications of GM-Crop Cultivation at Large Spatial Scales, Theorie in der Ökologie 14. Frankfurt, Peter Lang, http://www.mapserver.uni-vechta.de/generisk/gmls2008/index.php?proceedings=ja&call=ja

Then C. & Stolze M. (2010) Economic impacts of labelling thresholds for the adventitious presence of genetically engineered organisms in conventional and organic seeds, Report prepared for IFOAM, http://www.testbiotech.de/node/373

Then, C. & Tippe R. (2012): Europäisches Patentamt am Scheideweg – Patente auf Pflanzen und Tiere aus dem Jahr 2011, www.no-patents-on-seeds.org.

Tudisco, R., Mastellone, V., Cutrignelli, M.I., Lombardi, P., Bovera, F., Mirabella, N., Piccolo, G., Calabro, S., Avallone, L., Infascelli, F. (2010) Fate of transgenic DNA and evaluation of metabolic effects in goats fed genetically modified soybean and in their offsprings. Animal, 4(10): 1662-1671.

USDA Advisory Committee on Biotechnology and 21st Century Agriculture, AC21 (2012), Enhancing Co-existence: A Report of the AC21 to the Secretary of Agriculture, http://www.usda.gov/documents/ac21_report-enhancing-coexistence.pdf

Walsh, M.C., Buzoianu, S.G., Gardiner, G.E., Rea M.C., Gelencsér, E., Jánosi A., Epstein M.M., Ross, R.P., Lawlor, P.G. (2011) Fate of Transgenic DNA from orally odministered Bt MON810 maize and effects on immune response and growth in pigs. PLoS ONE 6(11): e27177, doi:10.1371/journal.pone.0027177.

Warwick, S.I., Legere, A., Simard, M.J., James, T. (2008) Do escaped transgenes persist in nature? The case of an herbicide resistance transgene in a weedy Brassica rapa population. Molecular Ecology, 17: 1387–1395. http://www.ask-force.org/web/Geneflow/Warwick-Escaped-Transgenes-2007.pdf

Zablotowicz R.M., Reddy K.N. (2007) Nitrogenase activity, nitrogen content, and yield responses to glyphosate in glyphosate-resistant soybean. Crop Prot 26:370-6

Zhang, L., Hou, D., Chen, X., Li, D., Zhu, L., Zhang, Y., Li, J., Bian, Z., Liang, X., Cai, X., Yin, Y., Wang, C., Zhang, T., Zhu, D., Zhang, D., Xu, J., Chen, Qu., Ba, Y., Liu, J., Wang, Q., Chen, J., Wang, J., Wang, M., Zhang, Q., Zhang, J., Zen, K., Zhang, C.Y. (2011) Exogenous plant MIR168a specifically targets mammalian LDLRAP1: evidence of cross-kingdom regulation by microRNA, Cell Research: 1-10