

## Feeding the World with GM Crops: Myth or Reality? June 2008

The recent sharp rises in world food and feed prices have been used by some to call for GM crops to be more widely grown because they yield more than conventional crops and therefore would feed more people. This briefing examines the evidence base for such claims, the underlying causes of the current crisis and looks briefly at the solutions (which will be examined in more detail in future briefings).

### Current Land Use for Food Production

According to biotech industry funded sources there were 114 million hectares of GM crops and trees grown in world in 2007<sup>i</sup>. This represents a tiny fraction (2.4%) of global agricultural and commercial forestry land. Thus nearly 98% of crops and plantation forest are non-GM. These include all major staple crops such as wheat, barley, oats, potatoes, sorghum, cassava and rice<sup>ii</sup>. The world relies on conventionally bred crops to feed people and will continue to do so.

The main GM crops are soya beans, maize, oilseed rape and cotton. GM soya and maize made up 82% of GM planting in 2007 according to industry sources. Although both crops can be used as food, most of the production is used to feed animals: between 66%<sup>iii</sup> and 90%<sup>iv</sup> of all soya production is fed to animals, mainly in intensive production systems where the ratio of plant protein to produce one unit of animal protein varies between 5 and 9 depending on the system being employed. There is therefore no problem in feeding the future population providing we adopt a sensible balance between plant and animal protein and land use.

There are only 23 countries growing GM crops in the world. Six countries account for 95% of the area – USA, Brazil, Argentina, Canada, India and China. India and China only grow a limited area of GM cotton. GM soya is by far the largest area being grown in USA, Argentina, Brazil and Canada (64% of the total).

Nearly all commercial GM crops have one or both of just two GM traits: herbicide-tolerance and insect-resistance. Herbicide tolerant versions of soya, maize, cotton and canola represent 4 of every 5 hectares (81%) of GM crops grown worldwide. Monsanto's 'Roundup Ready' herbicide tolerant crops account for around 99% of all GM herbicide tolerant crops – around 80% of all GM crops worldwide.

### Why are the prices of food rising so steeply?

Many analysts have written about why global food prices are rising steeply after years of relative stability, which translated into significant price reductions in real terms. In the UK, the proportion of household income being spent on food and non-alcoholic drinks in the early part of this decade was 16% compared to 21% in 1982<sup>v</sup>, showing that we have been in an era of cheap food and affluence. As usual it is the poor who suffer when prices rise, and there have been food riots in many countries in recent months, particularly those reliant on food imports. Some countries have suspended food exports to protect stocks for domestic consumption (eg India has suspended rice exports).

The reasons for the recent price increases put forward by food market analysts include<sup>vi, vii and viii</sup>

- Rising oil prices.
- Rising fertiliser prices.
- Increased production of biofuels diverting land away from food production driven by mandatory targets.
- Loss of productive land due to desertification, salination and soil erosion.
- Speculation on world commodity markets after loss in confidence in the financial markets following the "sub-prime crisis".
- Extreme weather such as prolonged drought in Australia, flooding and high winds linked to climate change.
- Low global reserves of wheat and maize.
- Increased affluence in many countries, especially China and India, leading to increased food consumption especially animal products. However despite these claims, both countries remain net exporters of agricultural products<sup>ix1</sup>.

The role that poverty and access to food play in causing hunger are also major factors in contributing to the food crisis, which is affecting the poorest people most.

Notably absent from these published analyses is any mention of GM crops.

However, it is clear that the biotechnology industry is seeking to exploit the current crisis for their own ends:

*"I think the debate about higher prices and being able to meet the demand of people in the world for food is a perfect opportunity to make the case (for GMO crops)...We may have a window of opportunity here and I would encourage you to exploit that."* Bob Stallman, President of the American Farm Bureau Federation speaking to the NFU conference 2008.

## **EU GMO Regulations and Price Feed Rises**

Food and feed price rises are happening globally despite the fact that GM crops are already being used. However, in Europe the rise in prices, particularly animal feed, has resulted in 3 pro-GM crop sectors attempting to implicate the EU's GMO regulatory policies and processes in the sudden price rises of the last 18 months. The clamour to relax GMO regulations to allow unapproved GMOs to enter the EU market below a certain threshold has not surprisingly been led by the biotech industry<sup>x</sup> supported by elements within the European Commission, especially Agriculture Commissioner Mariann Fischer Boel<sup>xi</sup>, and parts of the farming and animals feed sector<sup>xii</sup>.

GMO proponents say that:

- The EU Regulatory system has delayed the approval of GM crops being grown elsewhere limiting the choice of EU grain buyers.
- The complexity of the EU regulatory system means it is easier to export to less "fussy" countries and avoid the EU altogether.

The evidence available does not back up these claims. Monsanto's RR GM soya is the only GM soya available for commercial cultivation in the world. It has full approval for import into the EU for human and animal feed. GM presence in food, feed and derivatives has to be labelled if the presence is over 0.9% or if the presence below 0.9% cannot be shown to be "adventitious or technically unavoidable". If producers can prove the GM presence is adventitious or technically unavoidable the GM content would be exempt from labelling.

RR soya has been freely entering the EU market for animal feed since 1996 when it was first approved. The fact that RR soya is not extensively used in human food is entirely due to commercial decision made by the EU food manufacturers and retailers to ban GM ingredients in the late 1990s based on resounding public rejection. There are, therefore, no regulatory barriers to RR soya entering the EU markets and indeed it has been used in a range of animal feeds for over a decade.

And yet the price of Argentine soya meal (almost all GM) has gone up more (112.5%) than other feed crops including feed wheat (57%) for the year to May 2008<sup>xiii</sup>. Smaller price rises have been experienced for maize products, eg maize gluten (72%), despite the fact that several GM maize varieties are awaiting GM approval in the EU. There are already 8 GM maize crops approved for import into the EU. European Commission has forced through several approvals in recent times despite the lack of consensus amongst Member States. The free entry of GM crops for animal feed has been ongoing since 1996 assisted by the fact that products from GM fed livestock and poultry do not have to be labelled GM leaving consumers unable to make an informed choice when they buy meat, dairy products and eggs.

If the EU GMO regulatory system were affecting the price of feed to the extent claimed then it would have been expected that steep price rises would be seen for those crops where GM cultivation is taking place outside the EU, mainly maize and soya. However, price rises have hit every commodity, even those where there are no commercial GM varieties, such as wheat and rice. Price rises are affecting every country around the world, even the USA where GM crops have been most widely adopted and where there are the least exacting regulations to gain commercial approval.

The root causes of the current price increases in food commodities would appear to lie elsewhere than the EU GMO approval system. The two most significant changes in global food trading that have occurred in the last 18 months are the diversion of crops to biofuels, especially in the USA, and increased speculation on food prices. These, in combination with other factors listed above, would appear to be the main drivers of the current price increases, not a lack of GM in the EU.

## GM crops in the Future?

More than enough food is grown every year to feed the world's population. Hunger is a result of people being too poor to buy that food. Despite this, GM proponents continue to claim that increased yields and expanding available agricultural land are required to feed the predicted 9 billion global population in 2050. Here we examine these claims.

### Do GM Crops Yield More?

Data comparing the yields of GM crops and their conventionally bred counterparts shows that the current generation of GM crops have made no difference to yields, and in some cases actually reduce yield by as much as 10%. Independent studies comparing the same crop varieties with and without a GM construct in similar soils and environments show that, as with conventional crops, yield varies from season to season and between farms and individual fields. The Agricultural Science and Technology for Development (IAASTD) 4-year review<sup>xiv</sup> by 400 experts declined to endorse the current GM crops as providing a solution to world hunger or that they increased yields. Asked at a press conference if GM crops were the answer to world hunger IAASTD Director Professor Bob Watson (now Chief Scientist at Defra) said, "The simple answer is 'No'".<sup>xv</sup>

GM seed varieties are produced in two stages:

1. The engineering of the GM trait (herbicide tolerance or insect resistance (Bt)).
2. Conventional breeding of high yielding varieties.

Thus for any GM variety, improvements through conventional breeding will be more important than the genetic modification in boosting yields. In GM varieties some of the plant's energy is diverted into producing the extra GM proteins induced by the genetic engineering event(s), and this can cause a suppression of yield.

Studies which show GM to have reduced yields include:

Fernandez-Cornejo & Caswell, April 2006<sup>xvi</sup>

*"Currently available GE crops do not increase the yield potential of a hybrid variety. In fact, yield may even decrease if the varieties used to carry the herbicide-tolerant or insect-resistant genes are not the highest yielding cultivars."*

Elmore et al, 2001<sup>xvii</sup>

*"The high-yielding conventional soybean lines yielded 57.7 bushels per acre, their sister lines yielded 55 bushels per acre and the Roundup Ready soybeans yielded 52 bushels per acre. This research showed that Roundup Ready soybeans' lower yields stem from the gene insertion process used to create the glyphosate-resistant seed. This scenario is called yield drag. The types of soybeans into which the gene is inserted account for the rest of the yield penalty. This is called yield lag."*

Eliason R 2004<sup>xviii</sup>

*"This yield drag of RR soya is reflected in flat overall soybean yields from 1995 to 2003 (Figure 2), the very years in which GM soya adoption increased from nil to 81% of US soybean acreage. By one estimate, stagnating soybean yields in the US cost soybean farmers \$1.28 billion in lost revenues from 1995 to 2003"*

Benbrook C. 2001<sup>xix</sup>

*"There is voluminous and clear evidence that RR [Roundup Ready] soybean cultivars produce 5 percent to 10 percent fewer bushels per acre in contrast to otherwise identical varieties grown under comparable field conditions."*

Ma & Subedi, 2005<sup>xx</sup>

*"There are concerns over the economic benefits of corn (Zea mays L.) hybrids with the Bt trait transferred from Bacillus thuringiensis. A field experiment including three to seven pairs of commercial hybrids and their transgenic Bt near-isolines were grown side-by-side for three consecutive years in Ottawa, Canada (458170N, 758450W; 93 m above sea level) to determine (i) which hybrid had the highest yielding potential, (ii) if there was a differential response of Bt and non-Bt hybrids to N application, and (iii) under natural infestation of European corn borer (ECB), whether there was a yield advantage of Bt over non-Bt hybrids to justify their cost. We found that some of the Bt hybrids took 2–3 additional days to reach silking and maturity, and produced a similar or up to 12% lower grain yields with 3–5% higher grain moisture at maturity, in comparison with their non-Bt counterpart."*

Jost, P et al 2008<sup>xxi</sup>

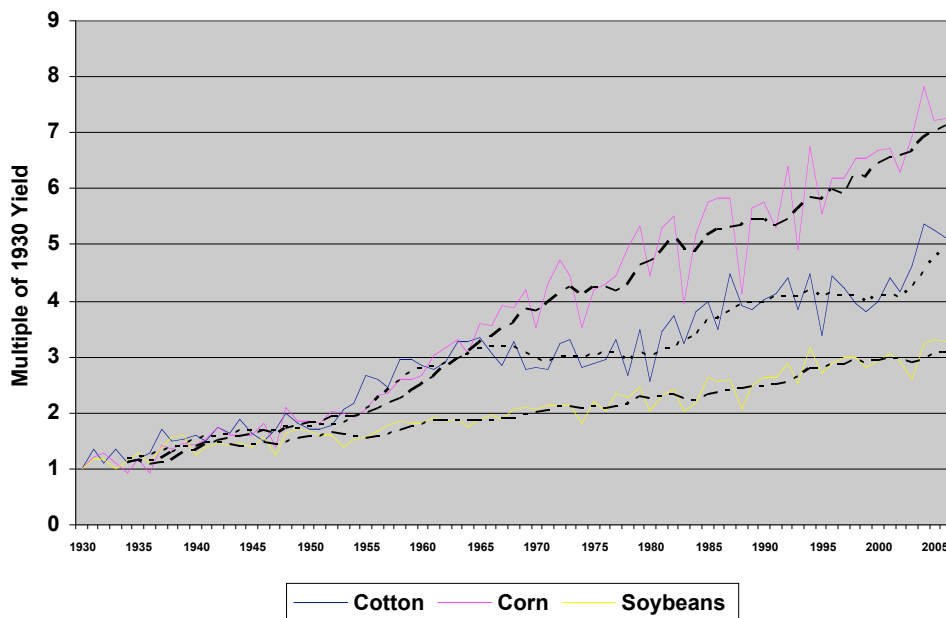
“In 2001 and 2002, selection of the Roundup Ready (RR) technology system resulted in reduced returns to the producer, while higher returns were attained from nontransgenic, Bollgard (B), and Bollgard/Roundup Ready (BR) technologies. In 2003, selection of the RR technology system or the Bollgard II/Roundup Ready (B2R) system reduced returns, while similar, higher returns were attained from nontransgenic, B, and BR technologies. In 2004, a nontransgenic system was superior to the BR, B2R, and Liberty Link (LL) systems in Tifton, but similar returns were achieved from nontransgenic, BR, and B2R technologies in Midville. Cultivar selection was important among the technology systems. Collectively these results indicate that profitability was most closely associated with yields and not the transgenic technologies.”

In a handful of cases when there is a severe pest outbreak GM Bt crops can yield more, but mitigating severe insect damage and increased yields are not the same thing. Similarly, claims about yield increases in herbicide tolerant crops are based on isolated examples where weed infestation was very high, eg Romania<sup>xxii</sup>, and almost any form of weed control be it, hoeing, GM/herbicide or straight herbicide application, would have increased yields.

### Non-GM breeding does increase yields

On the other hand, traditional plant breeding has produced a sustained rise in yields in the USA since the 1930s. There has been no additional increase in the annual rise since GM crops were introduced in 1996 (see below).

**Yield Increase of Corn, Cotton and Soybeans  
in the U.S.: 1930-2006**



Average yields of each crop expressed as multiple of the 1930 yield (i.e. “2” = twice the 1930 yield, “3” = triple the 1930 yield, etc). Coloured lines represent actual yields. Dotted/dashed lines represent 5-year moving averages calculated by averaging the yield multiples for the year in question and the 4 preceding years. This is based on data from US Department of Agriculture’s National Agricultural Statistics Service: [www.nass.usda.gov/QuickStats/indexbysubject.jsp?Pass\\_name=&Pass\\_group=Crops+%26+Plants&Pass\\_s ubgroup=Field+Crops](http://www.nass.usda.gov/QuickStats/indexbysubject.jsp?Pass_name=&Pass_group=Crops+%26+Plants&Pass_s ubgroup=Field+Crops).

Note the flat yields in soybeans as adoption of Roundup Ready soybeans grew to comprise 91% of all soybeans by 2006. Note also the flat yields in cotton throughout the 1990s to 2003, as genetically engineered cotton adoption rose to comprise 76% of all upland cotton planted in 2003. Cotton yield increases in 2004 to 2005 are attributable to favourable weather conditions, as documented in *Who Benefits from GM Crops? The Rise in Pesticide Use*, by Friends of the Earth International and the Center for Food Safety<sup>xxiii</sup>. The historical yield increase in corn has not accelerated in the biotech era.

## GM- Failing Technology

After 12 years of commercial production there are clear signs that GM crops are developing serious agronomic problems. These include the development of resistance in insects and weeds, problems with nutrient uptake, and long-term harm to biodiversity.

### Insect resistance

Bt crop are engineered to produce proteins that are toxic to the larvae of certain beetle and moth pests, eg the Western Corn Borer in maize and the boll worm in cotton. Bt is essentially a pesticide produced by and found in every part of the plant. Insect pests are therefore exposed to it all the time when they are feeding on the crop, which increases the chances of resistance evolving in pest populations. Despite efforts to prevent this happening, such as planting non-GM varieties on 40% of the field (known as refuges) to ensure that non-resistant individuals have a chance to survive and breed and thus prevent the resistant strains becoming dominant, resistant individuals are now being found in US cotton fields<sup>xxiv</sup>. The answer to this problem by the biotech industry is to engineer several different Bt genes in the crop, but what impact this will have on yield, the environment or non-target insects in unknown and remains to be studied. In 2007, EC Environment Commissioner Stavros Dimas, proposed that two Bt maize types should be banned because of their environmental impact<sup>xxv</sup>.

### Weed Resistance

Weeds resistant to Monsanto's Roundup and Bayer's Liberty weed killers used on GM herbicide tolerant crops have been increasing in North and South America. This problem has now serious enough for Monsanto to dedicate sections of their website to explaining to farmers how to deal with it<sup>xxvi</sup>. The problem is mainly associated with weeds, unrelated to the crop, evolving resistance the herbicides, such as ragweed (*Ambrosia artemisiifolia*) and horseweed (*Conyza Canadensis*)<sup>xxvii</sup>. In Argentina glyphosate (Roundup) resistant Johnsongrass (an arable weed), driven by GM agriculture, is a growing problem and already covers 7-10,000 ha<sup>xxviii</sup>.

The impact of resistance is already been recorded in the USA, where the promised reductions in pesticide usage on GM crops has been replaced by a net increase in use of Roundup, as well as older, more dangerous herbicides, to control the resistant weeds. The long-term functionality, not to mention sustainability, of GM herbicide tolerant crops is therefore under question. EuropaBio's Nathalie Moll admitted in February 2008 that "farmers have rotated RR crops, usually soya and maize, to the point that the weeds themselves are now Roundup resistant, which has resulted in much higher applications of Roundup along with a host of other chemicals"<sup>xxix</sup>.

### Nutrient Uptake Problems

Recent studies in Kansas and Indiana<sup>xxx</sup> have found manganese (Mn) deficiency in GM Roundup resistant soya crops, which does not occur in the traditionally bred varieties. Yields from the GM soya are lower unless manganese fertilisers are applied. Researchers have identified two possible causes of this down-side of GM crops:

- Glyphosate (RoundUp) binds soil manganese making it unavailable for the soya plants to take up.
- Glyphosate is toxic to soil microbes which help mobilise soil manganese.

### Damage to Biodiversity

GM crops have been grown for over a decade, but their long-term environmental impacts have not been fully investigated. Problems so far identified include the direct toxic effects on non-target insects and indirect food chain impacts. Research in the USA has found that plant debris from Bt maize crops could be toxic to aquatic invertebrates<sup>xxxi</sup>. In the UK, large scale field research in the Farm Scale Evaluations found that Liberty resistant oilseed rape and Roundup resistant beet crops significantly reduced the number of weeds, and hence weed seeds, on which insects and birds were dependent for food in arable fields. The overall conclusion was that these crops would cause long-term harm to farmland wildlife<sup>xxxii</sup> and they were not approved. Similar studies on other herbicide tolerant GM crops elsewhere in the world have not been carried out.

### GM Jam Tomorrow?

The first generation of GM crops (herbicide tolerant and insect resistant and combinations of the two) has not produced higher yields.

GM proponents have been made numerous claims about how GM technology will increase yields in the future or increase the land available for agriculture currently unusable because of droughts or salinity, but so far none of these promised crops have delivered. During the IAASTD report process, the biotechnology industry failed to provide evidence to support such claims<sup>xxxiii</sup>. The genetic engineering events involved are

far more complex than the single gene constructs found in the first and second generations of GM crops and therefore much more difficult to achieve. These include:

- Carbon 3 to Carbon 4 conversion
- GM nitrogen fixing crops.
- Drought tolerant crops.
- Saline tolerant crops.

### **Carbon3 to Carbon 4 conversion**

Genetic engineers have been trying to convert plants with Carbon 3 metabolisms(C3) which include most plants (eg trees, wheat and oilseed rape) to Carbon 4 metabolism (C4) plants. C4 plants, including maize and sugar cane, make more efficient use of carbon dioxide and water. Successful GM transformation would require changes the whole metabolism of the plant, which is why it has so far failed to produce any tangible results.

### **Nitrogen fixing GM crops**

Nitrogen fixation in leguminous plants (such as peas, beans and clover) is the symbiotic relationship between the plant and bacterium. The bacterium form root nodules where atmospheric nitrogen is fixed to form nitrates, which are then available to the plant to promote growth. Genetic engineers hope to be able to induce non-nitrogen fixing crops like wheat to produce nitrogen fixing nodules. This has not been achieved, probably because it requires multiple changes in the genetic structure of the receiving plant to work.

### **Drought Tolerant Crops**

GM scientists have long promised crops that can yield in dry conditions. The research mentioned above in the C3 to C4 conversion is linked to this. However, no seed will germinate and flourish in the absence of moisture.

Professor Ossama El-Tayeb, Professor Emeritus of Industrial Biotechnology at the University of Cairo seriously questioned whether drought tolerance through genetic manipulation will be achieved quickly<sup>xxxiv</sup>:

*"I wish to add that transgenicity for drought tolerance and other environmental stresses (or, for that matter, biological nitrogen fixation) are too complex to be attainable in the foreseeable future, taking into consideration our extremely limited knowledge of biological systems and how genetic/metabolic functions operate. Those who propagate the ideas that any biological function could be genetically manipulated are optimists who are probably victims of a consortium of "arrogant" scientists and greedy business who have strong control on policy making and the media."*

Traditional breeding has produced varieties that mature quickly, increasing the chances of achieving a harvestable crop in some dry years.<sup>xxxv</sup>

### **Saline Tolerance**

Many soils around the world have been rendered unusable by desertification and/or the overuse of irrigation producing toxic levels of salt in the soil. GM proponents have repeatedly claimed that GM crops can be produced to grow in salt contaminated land, thus increasing the area available for cropping. So far no commercial GM crops have been developed, although genes naturally occurring in wheat have been identified in Australia suggesting that marker assisted breeding (traditional plant breeding assisted by identifying the desired gene in the parent plants first) may be able to do what GM cannot.

Professor Tim Flowers of the School of Biological Sciences at the University of Sussex says: *"Evaluation of claims that biotechnology can produce salt-tolerant crops reveals that, after ten years of research using transgenic plants to alter salt tolerance, the value of this approach has yet to be established in the field. Biotechnologists have reasons for exaggerating their abilities to manipulate plants. If 'biotechnology' is to contribute tolerant crops, these crops may still be decades from commercial availability. The generation of drought tolerant crops is likely to have a similar period of development."*<sup>xxxvi</sup>

### **Conclusion**

The causes of the current food crisis are many and varied, but have not been linked by independent scientists to GM crops, poor yields or lack of available agricultural land. Claims by the GM industry that their products will ease, or even solve, hunger via these routes ring hollow.

GM crops have so far not increased yields or brought unusable land under agriculture above or beyond what is already being achieved by traditional breeding. GM Crops occupy only 2.4% of global agricultural and

commercial forestry land. In the next decade and beyond, world food supply will therefore be reliant on traditionally bred crops, which have produced a steady increase in yields since the 1930s. Traditional plant breeders are also producing varieties that cope better with environmental stress and plant diseases. Modern plant breeding techniques, such as marker assisted breeding, can help considerably in this process.

Genetic engineering has so far not produced one commercial drought tolerant, salt tolerant, higher yielding, nitrogen fixing crop despite two decades of transgenic plant research costing billions of pounds. Multiple gene events which impact on the whole physiology of the plant are proving much more tricky to achieve than the simple single and double trait insertions in the first and second generation GM crops.

Therefore, GM technology is an unnecessary cul-de-sac at best, and at worst a distraction diverting precious research time and funds away from cheap and more easily available solutions to agricultural problems.

The IAASTD report highlighted the need for more research money to train scientists and farmers (especially women) to develop sustainable agro-ecological farming techniques based around traditionally bred crops allied to a diet that strikes the right balance between plant and animal protein, waste and over consumption. The report also highlighted many socio-economic factors that cause hunger including: poverty, access to a balanced diet, civil unrest, and unfair trading practices and rules. Plant breeders' rights and patents were also found to be a barrier to providing access to good quality seeds for all farmers. These are the areas where reforms are urgently needed to allow the millions of farmers to adopt modern farming practices based on agro-ecological principles to produce good quality food but also meet the challenges of climate change, soil protection and enhancement, and of conserving natural resources and biodiversity as well as local cultures and traditions.

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<sup>i</sup> [www.isaaa.org/](http://www.isaaa.org/)

<sup>ii</sup> The total area of agricultural land in the world is 4.8 billion hectares including grassland for feeding livestock, and there are around 140 million hectares of commercial forestry (see page xvi in [ftp://ftp.fao.org/docrep/fao/008/A0400E/A0400E00.pdf](http://ftp.fao.org/docrep/fao/008/A0400E/A0400E00.pdf))

<sup>iii</sup> The Dutch Soy Coalition, 2008. *Soy- Big Business, Big Responsibility*.

<sup>iv</sup> [www.worldwatch.org/node/1665](http://www.worldwatch.org/node/1665)

<sup>v</sup> [www.statistics.gov.uk/downloads/theme\\_social/Family\\_Spending\\_2004-05/Family\\_Spending\\_2004-05\\_superseded.pdf](http://www.statistics.gov.uk/downloads/theme_social/Family_Spending_2004-05/Family_Spending_2004-05_superseded.pdf)

<sup>vi</sup> [www.ft.com/cms/s/0/2e5b2f36-1608-11dd-880a-0000779fd2ac.dwp\\_uuid=a955630e-3603-11dc-ad42-0000779fd2ac.html?nclink\\_check=1](http://www.ft.com/cms/s/0/2e5b2f36-1608-11dd-880a-0000779fd2ac.dwp_uuid=a955630e-3603-11dc-ad42-0000779fd2ac.html?nclink_check=1)

<sup>vii</sup> <http://news.bbc.co.uk/1/hi/business/7276971.stm>

<sup>viii</sup> <http://statistics.defra.gov.uk/esg/publications/Monthly%20brief/Annex%201%20Food%20and%20farming%20brief%20-%20impact%20of%20high%20commodity%20prices.pdf>

<sup>ix</sup> [www.agpolicy.org/weekcol/409.html](http://www.agpolicy.org/weekcol/409.html)

<sup>x</sup> [www.europabio.org/BrusselsDay/LLP\\_2008.pdf](http://www.europabio.org/BrusselsDay/LLP_2008.pdf)

<sup>xi</sup> [www.gmo-safety.eu/en/news/599.docu.html](http://www.gmo-safety.eu/en/news/599.docu.html)

<sup>xii</sup> [www.timesonline.co.uk/tol/news/uk/scotland/article3958943.ece](http://www.timesonline.co.uk/tol/news/uk/scotland/article3958943.ece)

<sup>xiii</sup> Figures from <http://www.mdcdatum.org.uk/FarmDataPrices/feedprices.html>

<sup>xiv</sup> [www.agassessment.org/docs/SR\\_Exec\\_Sum\\_210408\\_Final.pdf](http://www.agassessment.org/docs/SR_Exec_Sum_210408_Final.pdf)

<sup>xv</sup> See <http://www.independent.co.uk/environment/green-living/exposed-the-great-gm-crops-myth-812179.html>

<sup>xvi</sup> Fernandez-Cornejo & Caswell, April 2006. "The First Decade of Genetically Engineered Crops in the United States," U.S. Dept. of Agriculture, Economic Research Service. <http://www.ers.usda.gov/publications/EIB11/>, page 9.

<sup>xvii</sup> Elmore et al, 2001. *Glyphosate-Resistant Soybean Cultivar Yields Compared with Sister Lines*, Agron J 2001 93: 408-412, quote above from the University of Nebraska press release announcing this study: "Research Shows Roundup Ready Soybeans Yield Less," 16 May 2000. See <http://iannews.unl.edu/static/0005161.shtml>

<sup>xviii</sup> Eliason R and Jones L , August 2004 *Stagnating National Bean Yields* presentation to the Midwest Soybean Conference in Des Moines, Iowa.

<sup>xix</sup> Benbrook, C May 2001. "Troubled Times Amid Commercial Success for Roundup Ready Soybeans: Glyphosate Efficacy is Slipping and Unstable Transgene Expression Erodes Plant Defenses and Yields," AgBioTech InfoNet Technical Paper No. 4, p 3. [www.biotech-info.net/troubledtimes.html](http://www.biotech-info.net/troubledtimes.html)

<sup>xx</sup> Ma & Subedi, 2005. "Development, yield, grain moisture and nitrogen uptake of Bt corn hybrids and their conventional near-isolines," Field Crops Research 93 (2-3): 199-211, at [www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6T6M-4DRBBYB-1&\\_user=10&\\_coverDate=09%2F14%2F2005&\\_rdoc=1&\\_fmt=&\\_orig=search&\\_sort=d&\\_view=c&\\_acct=C00050221&\\_version=1&\\_urlVesion=0&\\_userid=10&md5=5299e6ebd64c6b4db4566ee6f44eced2](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T6M-4DRBBYB-1&_user=10&_coverDate=09%2F14%2F2005&_rdoc=1&_fmt=&_orig=search&_sort=d&_view=c&_acct=C00050221&_version=1&_urlVesion=0&_userid=10&md5=5299e6ebd64c6b4db4566ee6f44eced2)

<sup>xxi</sup> P. Jost, P et al 2008. "Economic Comparison of Transgenic and Nontransgenic Cotton Production Systems in Georgia," Agronomy Journal, Volume 100, Issue 1, 2008.

<sup>xxii</sup> [www.agbioforum.org/v8n4/v8n4a06-brookes.htm](http://www.agbioforum.org/v8n4/v8n4a06-brookes.htm)

<sup>xxiii</sup> Friends of the Earth International and the Center for Food Safety, January 2008, p. 13. See [http://www.centerforfoodsafety.org/WhoBenefitsPR2\\_13\\_08.cfm](http://www.centerforfoodsafety.org/WhoBenefitsPR2_13_08.cfm) for press release with link to report.

<sup>xxiv</sup> [www.sciencedaily.com/releases/2008/02/080207140803.htm](http://www.sciencedaily.com/releases/2008/02/080207140803.htm)

<sup>xxv</sup> <http://uk.reuters.com/article/environmentNews/idUKL2524238420071025>

<sup>xxvi</sup> [www.monsanto.com/monsanto/us\\_ag/content/stewardship/tug/2007TUGPDF.pdf](http://www.monsanto.com/monsanto/us_ag/content/stewardship/tug/2007TUGPDF.pdf)

<sup>xxvii</sup> [www.weedscience.org/Case/Case.asp?ResistID=5261](http://www.weedscience.org/Case/Case.asp?ResistID=5261) and [www.weedscience.org/Case/Case.asp?ResistID=5187](http://www.weedscience.org/Case/Case.asp?ResistID=5187)

<sup>xxviii</sup> CASAFE & CIAFA, 16 August 2006. Se confirma la resistencia de un biotipo de Sorghum halepense a glifosato en Tartagal, Salta.

[www.monsanto.com.ar/h/biblioteca/informes/AlepoResistComunicado2006.pdf](http://www.monsanto.com.ar/h/biblioteca/informes/AlepoResistComunicado2006.pdf)

<sup>xxix</sup> "GM crops: Biotech agriculture – Time to take GM seriously", Ethical Corporation, 7 February 2008. See

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[www.ethicalcorp.com/content.asp?ContentID=5684](http://www.ethicalcorp.com/content.asp?ContentID=5684)

<sup>xxx</sup> Gordon B, April 2007. "Manganese Nutrition of Glyphosate Resistant and Conventional Soyabeans". *Better Crops* Vol Number 4, pp12-13.

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