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Agricultural biotechnology: yield, competitiveness, jobs and environmental impact

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Introduction

There is much debate and controversy surrounding genetically modified (GM) crops, including acknowledged scientific uncertainty about impacts on farmers' livelihoods, the environment and human health. This briefing summarises research about agricultural biotechnology, including on yield, competitiveness, jobs and environmental impact.

1. GM crop yields

First-generation genetic modifications address production conditions (insect and weed control), and have not been modified to increase yield. Yields of both GM and conventional varieties vary depending on growing conditions, such as degree of infestation with insects or weeds, weather, and region of production.[i] Furthermore:

- A 2003 report published in the journal Science states that "***in the United States and Argentina, average yield effects [of GM crops] are negligible and in some cases even slightly negative***".[ii]
- The UN Food and Agriculture Organization's 2004 report on agricultural biotechnology acknowledges that GM crops can have reduced yields.[iii]
- In 1998 several universities carried out a study that demonstrated that, on average, Roundup Ready soy varieties were 4% lower in yield than conventional varieties.[iv]

2. Pesticide use

The growing of GM crops has resulted in increased herbicide use. In his exhaustive 2004 analysis of US Department of Agriculture pesticide usage data, Dr. Charles Benbrook at the Northwest Science and Environmental Policy Centre[v], a leading expert on GM crops, concludes that GM soy, maize, and cotton have led to a 122 million pound increase in pesticide use in the US since 1996, with a huge increase on herbicide-tolerant crops and a modest decrease on insect resistant crops.

3. Pesticide resistance and environmental impact

- Until the widespread adoption of genetically modified Roundup Ready crops, there were just two confirmed cases of glyphosate-resistant weeds. But by 2005, a growing list of weeds required applications of other, often more toxic, herbicides.[vi] Argentina may offer a lesson to the world in this respect. Roundup Ready soybeans comprise 99% of Argentine soybean hectarage. Roundup use on soybeans alone in Argentina has climbed from virtually zero in 1995/96 to 40 million kilograms in 2003/04, and 11 glyphosate-tolerant weed species have now been found in Argentina.[vii] The decreasing efficacy of Roundup is due in large part to the overuse of this single herbicide as the key method for managing weeds on millions of hectares.[viii] This underscores the fallacy of the 'one size fits all' approach so prevalent in modern-day farming.
- A recent paper by the Department of Plant Science at the University of Manitoba[ix], reports that transgene escape has become so frequent in Western Canada that farmers now expect the unintended presences of GM oilseed rape in their crops. After only three years of commercial growing multiple herbicide resistant volunteer oilseed rape plants were reported and after five years, farmers began to complain of GM oilseed rape plants contaminating their fields.
- The UK Government's Farm Scale Evaluations of GM crops[x] found that growing GM oilseed rape and sugar beet had a negative impact on wildlife than conventional equivalents. A follow up study also showed the first GM "superweed" in the UK. GM oilseed rape cross-bred with a common weed, Charlock, producing a herbicide resistant charlock plant.
- In 2005, a paper published in the scientific journal Pest Management Science[xi] stated: "There are many risks associated with the production of GM and herbicide-resistant crops, including problems with grain contamination, segregation and introgression of herbicide-resistant traits, marketplace acceptance and an increased reliance on herbicides for weed control."

4. Reduced soil erosion and fossil fuel use

It is claimed that growing GM crops results in reduced soil erosion and reduced fossil fuel use because no till or reduced till methods are used. However, whilst organic and integrated pest management systems have been successful in no till without the use of herbicides, these are overshadowed by GM and other industrial no-till, which is inherently dependent on the use of herbicides. Both herbicides and pesticides require fossil fuel use for their production and during use. Far from being low impact, this results in a cycle of increased use of herbicides and increased resistance. Dependence on herbicides is storing up future problems such as resistance, as well as health, water, environment and biodiversity impacts.

Research by the Home Grown Cereals Authority in the UK found that the environmental benefits of reduced tillage on farms are unclear and that successful systems are individually suited to soil, site, scale and management of an operation.[xii]

5. Health impacts of increased herbicide use

The two main herbicides used on GM crops are glyphosate (including Monsanto's Roundup) and glufosinate ammonium (including Bayer's Liberty). There is evidence that glyphosate can cause harmful chronic effects to health and Denmark has restricted its use following discoveries that it had contaminated groundwater, where most drinking water is obtained.[xiii] And, following a study peer reviewed by the European Food Safety Authority, the Swedish government has proposed that glufosinate is banned in the EU because of serious concerns about the risks for consumers, operators and the environment[xiv]

6. Genetically modified crops: EU competitiveness and job creation

The contribution of agricultural biotechnology to the EU economy has been greatly exaggerated:

Jobs

- According to the European Commission, 80% of the 94200 biotech jobs in the EU are health-related, and not in the agricultural biotech sector.
- Research for EuropaBio[xv] and the UK's Department of Trade and Industry[xvi] by the analysts, Critical I, together with the OECD's latest figures,[xvii] show that only about 7% of the biotechnology industry is made up of 'agricultural and marine' biotechnology. Even that figure overestimates the contribution of plant biotechnology because the category includes: '*veterinary healthcare, biopesticides, plant agriculture, food technology and processing, green biotech.*[xviii]
- The Critical I report also reported on the number of jobs in the agricultural and marine biotechnology sector in 7 EU countries with figures ranging from 94 in Ireland to 1638 in the UK. A report commissioned by the German group, BUND (Friends of the Earth Germany), has estimated that there are no more than 500 jobs

employed in the plant genetic engineering sector Germany,[xix] a number that is consistent with Critical I's more widely defined estimate. These figures indicate that the numbers are small and the sector is of trivial significance in Europe's overall economic performance or competitive potential.

Competitiveness

- According to an economic study of GM crops by Australia's Rural Industries Research and Development Corporation (RIRDC), "***the US share of the EU's maize imports has fallen to virtually zero (from around 2/3 in the mid-1990s), as has Canada's share of EU canola imports (from 54% in the mid-1990s). GM-adopting countries have lost market share to GM-free suppliers***".[xx]
- An Indian Government task force on biotechnology has recommended that India should not produce transgenic crops in commodities that the country exports. Many countries are closing their doors to GM produce so the report concludes that export crops, like soybean, basmati rice and Darjeeling tea should remain non GM. India has a trade interest in remaining GM-free. Due to its current ability to certify its soya as GM free, it has a market in countries like Japan and South Korea. If Indian farmers were to start cultivating genetically modified soybean, their produce would be unable to compete with the heavily subsidized soya produced by large countries like the US and Brazil; and on the other hand, it would loose the non GM market.[xxi]
- All major supermarkets in the UK are calling for Brazil to keep up its supply of non GM soy[xxii]
- Recent University of Essex research for the Soil Association (2006) on the socio economic impacts of organic farming found that
    - Organic farming in the UK provides 32% more jobs per farm than equivalent non-organic farms.
    - Organic farming is attracting younger people into farming compared to the farming industry as a whole. On average, organic farmers in the UK are seven years younger than non-organic farmers, whose average age is 56.
    - Organic farming is also attracting more new entrants to agriculture. A recent survey funded by the Department for Environment, Food and Rural Affairs in the UK of farms in England found that 31% of organic farmers had entered agriculture as an entirely new career and did not come from a farming family, compared to 21% of the non-organic sample.
    - Organic farms are also more likely to be involved in on-farm processing, marketing and retailing, building on the trust and connection between farmers and consumers of their food.[xxiii]
- A 22-year comparative study looking at organic and conventional agriculture by Cornell University[xxiv] found that despite higher labour costs, the higher prices that organic foods command in the marketplace still make the net economic return per acre either equal to or higher than that of conventionally produced crops.
- A 5-year study by France's National Institute of Agronomic Research (INRA) has found that grass-fed livestock farms were more competitive and profitable than intensive farms using chemical inputs and soja/maize animal feed.[xxv]

7. EU food production chain

The vast majority of the retailers and food and drink companies in the European Union have a non-GM food policy and many have had this policy in place for a number of years. With estimated food and drink sales worth EUR 1.069 billion in Europe one of the worlds largest food markets, is firmly closed to GM labelled food, and there is nothing to indicate that this is likely to change any time soon. The trend amongst European based companies is clearly towards implementing non-GM ingredients policies and where non-GM policies have already existed for many years there is evidence of the policy being extended internationally as part of a company wide commitment by an increasing number of companies. Stakeholders in the food production chain whether they are farmers, importers and exporters of commodity crops, policy makers, investors or other food producers and retailers take account of these strong market signals.

The introduction of GM crops has brought only costs (and no benefits) to some sectors because of the need to ensure that non-GM and organic products do not contain GM contamination. This is of particular importance because products that contain more than 0.9% GM have to be labelled. The burden of ensuring that food is non-GM or organic has largely fallen on the producers of such food, not the GM-crop producers
If GM crops are grown extensively in Europe, this would add considerably to the costs of producing non-GM foods.

8. Food and feed quality

Worldwide, 73 per cent of the GM crops in the world are developed for herbicide tolerance while 18 per cent are developed for resistance to insects and 8 per cent developed contain both traits. Only 0.1 per cent of GM crops are for yield improvement and vitamin enrichment. [xxvi]

Virtually all GM crops currently in the pipeline for authorisation into the EU are for herbicide tolerance or resistance to insects. Expectations for "second generation GM crops" for the market in industrialised countries, including "functional foods" to produce altered nutritional profiles, have not been met as the traits that researchers want to enhance are likely to involve several genes and complex interactions between the plant and its environment.

There is also little evidence to support the role of functional foods, whether genetically modified or not, in reducing diet-related disease and improving public health. However, there is considerable evidence to support the health benefits of consuming more fruits and vegetables and other foods naturally rich in vitamins, minerals, and other micronutrients, rather than the consumption of individual nutrients. It can be questioned as to whether the development of functional foods for the EU would improve nutrition and health of citizens, or a lucrative marketing opportunity for food processing companies[xxvii].

Any development of GM crops to produce pharmaceutical products is likely to result in more costs than benefits, especially if the crops involved are food crops. The current GM rice contamination scandal is the second time in two years that the European Commission has put in place Emergency Measures to prevent unauthorised GMOs from entering the EU market, the previous one being Bt 10 maize contamination. And contamination of the food chain with a pharmaceutical crop has already occurred in the US. In November 2002, the US Department of Agriculture announced it had quarantined, and later destroyed, over 4 million euros worth of soya beans destined for human food after finding ProdiGene's GM pharmaceutical maize mixed with the soya beans.[xxviii]

9. Impacts on global poverty and malnutrition

In India in 2002, there were 65 million tons of surplus food but 350 million people went undernourished. Hunger results from the inability of the poor to access food, and from policies that further marginalise the poverty-stricken.

Professor Tim Flowers of the School of Biological Sciences at the University of Sussex has stated: "*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*."[xxix]

A University of Cornell study into the socio economic impacts of cotton that is genetically modified to produce insecticide (Bt cotton) found that reduction in pesticide use in the first few years, farmers then had to spray more pesticide use which coupled with the higher cost of the seeds resulted in an income loss of 8%. The study was conducted by Per Pinstrup-Andersen the 2001 Food Prize Laureate, Shenghui Wang of the World Bank and Cornell Professor David R. Just. Their study showed that populations of other insects (not killed by Bt) were becoming so problematic that farmers are having to spray their crops up to 20 times a growing season to control them. The study concluded that secondary pest problems could become a major threat in countries growing Bt cotton.[xxx]

The case of vitamin A enhanced rice

Questions need to be asked concerning this rice, and on the fact that non GM alternatives exist.
Who decided that vitamin A is the most essential micronutrient to be incorporated in rice? Why not vitamin B complex?
After all, several hundred million people in India alone suffer from malnutrition, compared to only half a million people worldwide who go blind from vitamin A deficiency. In India alone, some 12 million people suffer from vitamin A deficiency but the number lacking adequate vitamin B complex is several times higher. A majority of acutely malnourished people whom the proponents of "golden rice" claim they want to help cannot afford to buy rice from the market. If these poor people cannot buy ordinary rice, how will they pay for "golden rice"? If these hungry millions could meet their daily rice requirement, there would be no malnutrition in the first place.
Non genetically modified solutions exist. For example, research scientists in Uganda have come up with a non GM Vitamin A fortified sweet potato developed in line with the United Nations Millenium Development Goals (MDGs)[xxxi]

Biotechnology companies have acknowledged that the commercialization of drought-resistant crops is a long way off, and would in any case be first grown in the US. The biotech corporation Monsanto has encouraged Kenyan farmers in drought-prone areas to lessen their reliance on maize and plant more crops such as sorghum, cassava and sweet potatoes that can better withstand lack of rainfall. Another biotech corporation, Pioneer, is telling Kenyan farmers to use hybrid drought resistant maize.[xxxii] A University of Essex review (2001)[xxxiii] of 208 non-GM projects/initiatives from 52 countries, adopted by 8.98 million farmers on 29 million hectares of land in Asia, Africa and Latin America, reported yield increases of 50-100% for rainfed agriculture, and 5-10% for irrigated crops.

[i] European Commission, 2000. Economic Impacts of Genetically Modified Crops on the Agri-food sector. http://europa.eu.int/comm/agriculture/publi/gmo/cover.htm
[ii] Qaim, M. and Zilberman, D., 7 February 2003. *"Yield Effects of Genetically Modified Crops in*

Developing Countries" in Science, vol. 299, p. 900.
[iii] FAO, 2004. *Agriculture Biotechnology: Meeting the Needs of the Poor?* The State of Food and Agriculture 2003, p. 50.
[iv] Oplinger, E.S. et al., 1999. *Performance of Transgenetic Soyabeans, Northern US.* http://www.biotech-info.net/soybean_performance.pdf and Gianessi, L.P., April 2000. *Agriculture Biotechnology: Benefits of Transgenic Soybeans.* National Center for Food and Agricultural Policy, p. 63. http://www.ncfap.org/reports/biotech/rrsoybeanbenefits.pdf
[v] Benbrook, C,. October 2004. Genetically Engineered Crops and Pesticide Use in the United States: The First Nine Years. BioTech Infonet Technical Paper No7 http://www.biotech-info.net/Full_version_first_nine.pdf
[vi] Ibid
[vii] Benbrook, C. January 2005. Rust, Resistance, Run Down Soils and Rising Costs – Problems Facing Soybean Producers in Argentina, Ag Biotech Infonet Technical Paper No8, p33
[viii] Delta Farm Press, 2005. *No Quick Cures for Glyphosate-ResistantWeeds.* http://deltafarmpress.com/news/050927-glyphosate-resistant/; Business Journal, 24 September 2005. *Major Yield Losses and Harvest Headaches.* http://bjournal.com/2005/content/article_views.php?ID=756&Author=56 Professor Tom Mueller, University of Tennessee weed scientist, said that *"Palmer pigweed that is not killed by glyphosate will cause major yield losses and harvest headaches for soybean, cotton and other row crop producers. [...] It is essential to use more than one herbicidal mode of action on your fields."*
[ix] "Coexistence of GM and non-GM crops in Canada: current status and future direction", R.C. Van Acker. Paper presented at the COEXTRA conference in Montpellier, France, November 2005
[x] http://www.defra.gov.uk/environment/gm/research/epg-1-5-137.htm
[xi] "Herbicide-resistant crops and weed resistance to herbicides", Micheal DK Owen and Ian A Zelaya , Iowa State University, Ames, IA 50011-1011, USA, Pest Management Science 61:301–311 (2005)
[xii] HGCA Research Review 48, 'Reduced cultivations for cereals: research, development and advisory needs under changing economic circumstances' March 2002 - http://www.hgca.com/soil2crop/library/library.htm
[xiii] http://www2.mim.dk/nyheder/presse/Dep/040603_glyphosat.htm
[xiv] http://www.efsa.eu.int/science/praper/conclusions/895/praper_ej27_conclusion_glufosinate_en1.pdf.
[xv] Critical I (2005) Biotechnology in Europe: 2005 comparative study. EuropaBio: Brussels. www.europabio.org
[xvi] Critical I (2005) Comparative Statistics for the UK, European and US biotechnology sectors. Analysis year 2003. Department of Trade and Industry:www.dti.gov.uk
[xvii] van Beuzekom B & Arundel A (2006) OECD biotechnology statistics – 2006. OECD: Paris.
[xviii] Personal communication (Greenpeace), John Hodgson, Critical I June 2, 2006. "Crop seed producers will be included in Ag/Marine, but only if they use advanced techniques to produce the seed product. In short hand, GM seed producers are included but conventional breeders are not. In fact we always look to see that a seed producer has an R&D facility on site before we will include them. Thus not every national node of every seed producer will be included: only those that have active, high-technology R&D associated with a
particular operational unit. …Animal vaccine producers - are in Ag/Marine, with the same provisos about the use of high technology methods (shorthand for GM, but the use of advanced adjuvants would also be included)…. Food technology companies - the production of biological technologies for food processing (e.g. production of pectinases for fruit processing) would be included, but the food companies that use such processing aids would not.
[xix] [xix]BUND (2006) "Grüne Gentechnik" als Arbeitsplatzmotor? http://www.bund.net/lab/reddot2/pdf/gentechnik_arbeitsplaetze.pdf
[xx] http://www.geneethics.org/Default.aspx?tabid=85
[xxi] GM crops a losing proposition , Suman Sahai, The Times of India, 1 Feb 2006 http://timesofindia.indiatimes.com/articleshow/1394695.cms
[xxii] . See British Retailer statement at http://www.saveourseeds.org/downloads/BRC%20Position%20on%20non%20GM%20july%202005.pdf[xxii]
[xxiii] Morison J, Hine R & Pretty J (2005). Survey and analysis of labour on organic farms in the UK and Republic of Ireland. International Journal of Agricultural Sustainability 3(1):24-43, and Maynard R & Green M (2006). Organic works: Providing more jobs through organic farming and local food supply. Soil Association, Bristol.
[xxiv] Pimentel, D. et al; Cornell University in Bioscience, Volume 55:7; July 2005
[xxv] CEDAPA-INRA, "programme système Terre et eau - 1994-1999", 1999, 350p.
[xxvi] The Indian Council of Medical Research (ICMR), July 2004
[xxvii] "The next generation of GM foods: Good for Whose Health?" Genewatch UK, Briefing Number 10, April 2000
[xxviii] http://www.aphis.usda.gov/lpa/news/2002/11/prodigene.html
[xxix] http://www.ids.ac.uk/ids/env/biotech/confforum.html
[xxx] "Seven-year glitch: Cornell warns that Chinese GM cotton farmers are losing money to 'secondary' pests", Susan Lang, July 2006
[xxxi] "Vitamin A fortified potato to combat blindness" http://www.newvision.co.ug/D/9/37/530777?highlight&q=genetically
[xxxii] Source: Drought-resistant GM seeds won't benefit Kenyans for the next decade, By Kevin J. Kelley;The Nation (Kenya), 31 January 2006 http://www.nationmedia.com/eastafrican/current/News/news300120065.htm Reported by GMwatch
[xxxiii] Pretty, J. and R. Hine (2001) Reducing food poverty with sustainable agriculture: a summary of new evidence, Occasional Paper 2001-2002, Centre for Environment and Society, University of Essex