Focus on environmental impacts

Biotech crops: evidence, outcomes and impacts 1996-2007

OCTOBER 2009

FOREWORD

This brief is intended for use by a wide range of people with interests in agriculture and the environment. As a summary of the key findings relating to the impact of biotech crops (1996-2007), this brief focuses on environmental effects associated with pesticide usage and greenhouse gas (GHG) emissions, as detailed in '*Global impact of biotech crops: socio-economic and environmental effects 1996-2007*'[1], by Graham Brookes & Peter Barfoot[2]

[1] www.pgeconomics.co.uk/pdf/2009globalimpactstudy.pdf. A shorter version of the report can be found in the peer reviewed scientific journal, AgBioForum, Volume 12(2): 184-208 www.agbioforum.org and in the journal, Outlooks on Pest Management, Volume 20(6), Dec. 2009. The food security analysis presented in this document is derived from data contained in the full report.

[2] Of PG Economics Ltd, a UK-based independent consultancy. PG Economics specializes in analyzing the impact of new technology in agriculture. Their research into biotech crops has been widely published in scientific journals including Agbioforum and the International Journal of Biotechnology.

INSIDE THIS BRIEF

Environmental benefits

Pesticide reductions

Since 1997, the use of pesticides on the biotech crop area has been reduced by 359 million kg of active ingredient (ai), an 8.8% reduction. This is equivalent to one and a quarter times the total volume of pesticide active ingredient applied to arable crops in the EU (27) in a year.

Whilst changes in the volume of pesticides applied to crops can be a useful indicator of environmental impact, it is an imperfect measure because it does not account for differences in the specific pest control programmes used in biotech and conventional cropping systems. Using a more robust and comprehensive measure of the environmental impact associated with pesticide use, the environmental impact quotient (EIQ[3]), this measure shows that the environmental impact associated with herbicide and insecticide use on the area planted to biotech crops between 1996 and 2007 fell by 17.2% (Table 1).

In both absolute and per hectare usage terms, the largest environmental gain has been associated with the adoption of biotech Insect Resistant (IR) cotton. Since 1996, farmers have used 147.6 million kg less insecticide in biotech Insect Resistant (IR) cotton crops (a 23% reduction), and this has reduced the associated environmental impact of insecticide use on this crop area by 27.8%.

Important environmental gains have arisen from the use of biotech Herbicide Tolerant (HT) soybeans, reflecting the large share of global soybean plantings accounted for by biotech soybeans (Table 1). The volume of herbicides used in biotech soybean crops decreased by 73 million kg (1996-2007), a 4.6% reduction, and, the overall environmental impact associated with herbicide use on these crops decreased by 20.9% (relative to the volume that would have probably been used if this cropping area had been planted to conventional soybeans). Important environmental gains have also arisen in the maize and canola sectors (Table 1).

TABLE 1:

Global impact of herbicide and insecticide use changes from biotech crops 1996-2007

Trait	Change in volume of active ingredient used (million kg)	Change in field EIQ impact (in terms of million field EIG/ha units	% change in active ingredient use on biotech crops	% change in environmental impact associated with herbicide & insecticide use on biotech crops
GM herbicide tolerant soybeans	-73.0	-6,283	-4.6	**-20.9**
GM herbicide tolerant maize	-81.8	-1,934	-6.0	**-6.8**
GM herbicide tolerant cotton	-37.0	-748	-15.1	**-16.0**
GM herbicide tolerant canola	-9.7	-443	-13.9	**-25.8**
GM insect resistant maize	-10.2	-528	-5.9	**-6.0**
GM insect resistant cotton	-147.6	-7,133	-23.0	**-27.8**
Totals	**-359.3**	**-17,069**	**-8.8**	**-17.2**

In terms of the division of the environmental benefits associated with less insecticide and herbicide use, over half of the environmental benefits (1996-2007) have been in developing countries (52%). The vast majority of these environmental gains have been from the use of biotech IR cotton and HT soybeans.

[3] See Brookes & Barfoot (2008) for further details

Greenhouse gas emission (GHG) cuts

Biotech crops have also delivered significant savings in greenhouse gas emissions. In 2007, the 111 million hectares of biotech crops facilitated a 14.2 billion kg reduction in carbon dioxide (CO_2) emissions, equivalent to removing 6.3 million cars from the roads for a year (equal to 24% of all registered cars in the UK off the roads for a year (Table 2)).

TABLE 2:

Impact of biotech crops on carbon emissions 2007

Carbon dioxide savings from reduced fuel use (billion kg CO_2)	1.14
Additional soil carbon sequestration savings (billion kg CO_2)	13.10
Total CO_2 savings (billion kg CO_2)	14.24
Car equivalents removed from road (million)	6.3

The GHG emission reductions derive from two principle sources:

- Reduced fuel use from less frequent herbicide or insecticide applications and a reduction in the energy use in soil cultivation. The fuel savings associated with making fewer spray runs (relative to conventional crops) and the switch to conservation, reduced and no-till farming systems, have resulted in permanent savings in CO_2 emissions. In 2007, this amounted to about 1,144 million kg (arising from reduced fuel use of 416 million litres: table 2). Over the period 1996 to 2007 the cumulative permanent reduction from fuel use is estimated at 7,090 million kg CO_2 (arising from reduced fuel use of 2,578 million litres)
- The use of 'no-till' and 'reduced-till'[4] farming systems. These production systems have increased significantly with the adoption of biotech HT crops because the HT technology has improved growers ability to control competing weeds, reducing the need to rely on soil cultivation and seedbed preparation as means to getting good levels of weed control. As a result, tractor fuel use for tillage is reduced, soil quality is enhanced and levels of soil erosion cut. In turn, more carbon remains in the soil and this leads to lower GHG emissions. Based on savings arising from the rapid adoption of no till/ reduced tillage farming systems in North and South America, an extra 3,570 million kg of soil carbon is estimated to have been sequestered in 2007 (equivalent to 13,103 million kg of carbon dioxide that has not been released into the global atmosphere). Cumulatively the amount of carbon sequestered is probably higher due to year-on-year benefits to soil quality. However, due to the lack of data on the crop area in continuous no-till systems it is not possible to confidently estimate cumulative soil sequestration gains.

Other impacts

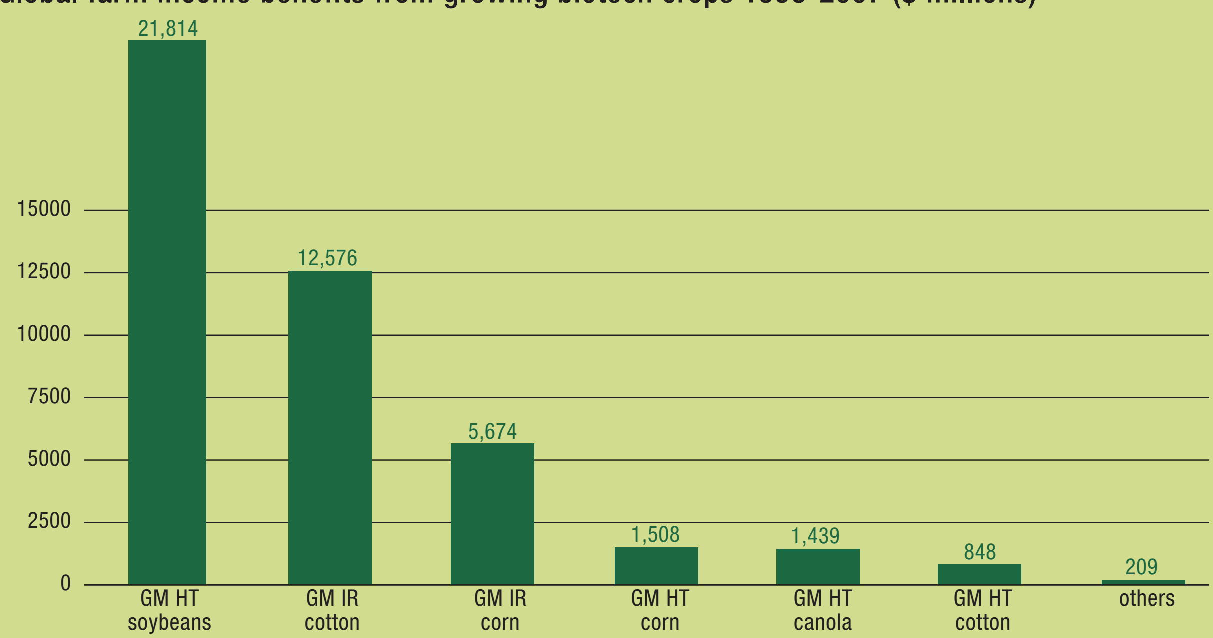
Farm income impacts

GM technology has had a very positive impact on farm income derived from a combination of enhanced productivity and efficiency gains (Figure 1). Between 1996 and 2007, farm incomes increased by $44.1 billion. In 2007, the direct global farm income benefit was $10.1 billion, equivalent to adding 4.4% to the value of global production of the four main crops of soybeans, corn, cotton and canola.

[4] No-till farming means that the ground is not ploughed at all, while reduced tillage means that the ground is disturbed less than it would be with traditional tillage systems. For example, under a no-till farming system, soybean seeds are planted through the organic material that is left over from a previous crop such as corn, cotton or wheat.

FIGURE 1:

Global farm income benefits from growing biotech crops 1996-2007 ($ millions)



Note: Others = virus resistant papaya and squash

Improving economic well being and food security

The extra farm income from growing biotech crops, when spent on goods and services, has had a positive multiplying effect on local, regional and national economies. In developing countries, the additional income has enabled more farmers to consistently meet their food subsistence needs and to improve the standards of living of their households. In India and the Philippines, where farmers use biotech IR cotton and corn respectively, their household incomes have typically increased by over a third.

Biotech crops have also, since 1996, added important volumes to global production of corn, cotton, canola and soybeans (Table 3).

This additional production arising from biotech crops (1996-2007) has also contributed enough energy (in kcal terms) to feed about 402 million people for a year (additional production in 2007 contributed enough energy to feed 88 million, similar to the annual requirement of the population of the Philippines: see appendix for assumptions and calculations). Important contributions to meeting the protein and fat requirements of considerable numbers of people have also arisen.

TABLE 3

Additional crop production arising from positive yield/production effects of biotech crops

	1996-2007 additional production (million tonnes)	2007 additional production (million tonnes)	Per cent change in production 2007 on area planted to biotech crops
Soybeans	67.80	14.46	29.8
Corn	62.42	15.08	7.6
Cotton	6.85	2.01	19.8
Canola	4.44	0.54	8.5

Appendix

Food security assumptions and calculations

Human food requirements per day (recommended daily allowances)

	MALE	FEMALE	AVERAGE
Energy (kcal)	2,900	2,200	2,550
Proteins (grams)	63	50	56.5
Fat (grams)	100	78	89

Source: FAO

Crop key nutrition composition (per kg of edible material)

	Energy (kcal)	Proteins (grams)	Fat (grams)
Corn	3,650	94	47
Canola oil	8,840	0	1,000
Canola meal	3,540	380	38
Soybean oil	8,840	0	1,000
Soybean meal	3,370	485	10
Cottonseed oil	8,840	0	1,000
Cottonseed meal	3,450	410	21

Source: USDA - Nutritional database for standard reference **www.usda.gov/data/feedgrains**

Main constituents of oilseeds (source: Soya & Oilseed Bluebook)

- Soybeans: 79.2 per cent meal, 17.8 per cent, oil, 3 per cent waste
- Canola: 59 per cent meal, 38 per cent oil, 3 per cent waste
- Cottonseed: 44.9 per cent meal, 16.2 per cent oil, 8.2 per cent lintners, 26.7 per cent hulls, 4.1 percent waste

Assumption on corn utilization – 99 per cent usable

Assumptions for uses of crops

	Food	Feed	Industrial (non-food)
Corn	30%	50%	20%
Soy oil	98%	0%	2%
Soy meal	0%	100%	0%
Canola oil	60%	0%	40%
Canola meal	0%	100%	0%
Cottonseed oil	50%	0%	50%
Cottonseed meal	0%	50%	50%

Source: derived from USDA ERS Feed Grains database **www.ers.usda.gov**

The following simplifying assumptions were used:

- As most corn and oilseeds at the global level are used in pig and poultry rations, all usage is assumed to be in these two sectors;
- Corn: 2.6 kg corn produces 1 kg of poultry meat at the consumer level, 6.5 kg of corn produces 1 kg of pig meat at the consumer level (source: USDA ERS – www.ers.usda/amberwaves/february2008/features/cornprices.htm). Readers should note these are conservative estimates;
- Feed conversion ratios of 1.8 kg feed produces 1 kg of chicken (live weight) and 3 kg of feed produces 1kg of pig (live weight) – typical feed conversion rates in developed countries for poultry are 1.7/1.75:1 and for pig meat are 2.5/2.8:1, hence the conversion rates used are conservative;
- Conversion of live weight to meat eaten by a consumer – for poultry assumes 50% of live weight converted to meat and for pig meat assumes 35% conversion;
- Corn constitutes 70% of a typical poultry feed ration and 75% of a typical pig ration;
- Meals (from soy, canola and cottonseed) are assumed to supply the main part of the protein requirement in the feed ration with incorporation rates of 25% in poultry feed and 20% in pig feed;
- Based on the above assumptions, it takes 0.93 kg of meal to produce 1 kg of poultry meat (at the consumer level) and 1.73 kg of meal to produce 1kg of pig meat (at the consumer level).