

# **Socio-economic impacts of GM crop technology: 'second round' impacts**

## **Briefing note**

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## 1. Introduction

This paper summarises the findings of a literature search into 'second round' socio-economic impacts of genetically modified (GM) crop technology, since it was first adopted on a broad commercial scale, in 1996. In contrast to the literature and analysis available on the 'first round' socio-economic effects (see separate paper), there is a much more limited literature available examining 'second round' impacts.

The paper is structured by socio-economic impact/effect, with brief summaries of relevant analysis from the available literature. It was not an intention of the paper to provide full and detailed information on each paper cited (eg, relating to methodology of research for each paper), and readers wishing to explore such aspects further should consult the original literature.

## 2. Second round socio-economic effects identified in the literature

### *2.1 Distribution of technology gains: farmers and the input supply chain*

**Brookes G & Barfoot P (2009)** examined this issue in terms of the cost farmers pay for accessing GM technology relative to the total trait benefit (measured in terms of the farm income gain plus the cost of accessing the technology at the farm level). Table 1 summarises their analysis across the four main biotech crops for 2007, and identified that the total cost was equal to 24% of the total technology gains (inclusive of farm income gains plus cost of the technology payable to the seed supply chain<sup>1</sup>).

For farmers in developing countries the total cost was equal to 14% of total technology gains, whilst for farmers in developed countries the cost was 34% of the total technology gains. Whilst circumstances vary between countries, the higher share of total technology gains accounted for by farm income gains in developing countries relative to the farm income share in developed countries reflects factors such as weaker provision and enforcement of intellectual property rights in developing countries and the higher average level of farm income gain on a per hectare basis derived by developing country farmers relative to developed country farmers.

**Table 1: Cost of accessing GM technology (million \$) relative to the total farm income benefits 2007**

	Cost of technology : all farmers	Farm income gain: all farmers	Total benefit of technology to farmers and seed supply chain	Cost of technology : developing countries	Farm income gain: developing countries	Total benefit of technology to farmers and seed supply chain: developing countries
GM HT	931	3,935	4,866	326	2,560	2,886

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<sup>1</sup> The cost of the technology accrues to the seed supply chain including sellers of seed to farmers, seed multipliers, plant breeders, distributors and the GM technology providers

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soybeans						
GM IR maize	714	2,075	2,789	79	302	381
GM HT maize	531	442	973	20	41	61
GM IR cotton	670	3,204	3,874	535	2,918	3,453
GM HT cotton	226	25	251	8	8	16
GM HT canola	102	346	448	N/a	N/a	N/a
<b>Total</b>	<b>3,174</b>	<b>10,081</b>	<b>13,255</b>	<b>968</b>	<b>5,829</b>	<b>6,797</b>

1. N/a = not applicable. Cost of accessing the technology is based on the seed premia paid by farmers for using GM technology relative to its conventional equivalents. Total farm income gain excludes £26 million associated with virus resistant crops in the US

**Qaim & Traxler (2005)** identified that, in terms of aggregate welfare, the economic surplus associated with GM HT soybeans in Argentina in 2001 was \$335 million, of which farmers were able to capture 90% of the benefit. In contrast, they estimated that in the US, the share of the total trait benefit (of GM HT soybeans) was, the supply chain and farmers captured 57% and 43% respectively of the benefit. This greater share of the supply chain in the US relative to Argentina reflected the more effective Intellectual Property Rights (IPR) protection available in the US.

**Pray et al (2002)** examined these issues relating to the adoption of GM IR cotton in China but extended their analysis to consider consumer level impacts. They concluded that because the Chinese government bought all of the cotton at a fixed price, no benefits were passed on down the supply chain to consumers. Also because of weak intellectual property rights the major share of benefits was retained by farmers, with little accruing to the technology providers (public and private sector).

**Traxler et al (2001) and Traxler and Godoy-Avila (2004)** similarly found in Mexico (adoption of GM IR cotton) that 85% of the total benefits from adoption went to farmers with only 15% earned by the seed suppliers and technology providers.

**Trigo and CAP (2006)** estimated the distribution of accumulated benefits generated by GM HT soybeans in Argentina in the period 1996 to 2005, to be farmers 78%, the supply chain 9% and the government (from export taxes), 13%.

Overall, all of the papers that have examined this issue have consistent findings, namely that a significant majority of the benefit has accrued to farmers (relative to the supply chain, including the providers of the technology).

### Relevant references in full

Brookes G & Barfoot P (2009) GM crops: global socio-economic and environmental impacts 1996-2007. PG Economics. [www.pgeconomics.co.uk](http://www.pgeconomics.co.uk) Also Global impact of biotech crops: income and production effects 1996-2007, Agbioforum (2009) forthcoming

Pray C et al (2002) Five years of Bt cotton in China – the benefits continue, *The Plant Journal* 2002, 31 (4) 423-430. Also, Pray et al (2001) Impact of Bt cotton in China, *World Development* 29 (5), 813-825

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Qaim M & Traxler G (2005) Roundup Ready soybeans in Argentina: farm level & aggregate welfare effects, *Agricultural Economics* 32 (1) 73-86

Traxler G et al (2001) Transgenic cotton in Mexico: economic and environmental impacts, ICABR conference, Ravello, Italy

Traxler and Godoy-Avila (2004): Transgenic cotton in Mexico, *Agbioforum* 7, (1-2), 57-62, [www.agbioforum.org](http://www.agbioforum.org)

Trigo E & Cap E (2006) Ten years of GM crops in Argentine agriculture, *ArgenBio*, Argentina

### **2.2 Impact on prices**

Assessing the impact of the biotech agronomic, cost saving technology such as herbicide tolerance and insect resistance on the prices of soybeans, maize, cotton and canola (and derivatives) is difficult. Current and past prices reflect a multitude of factors of which the introduction and adoption of new, cost saving technologies is one. This means that disaggregating the effect of different variables on prices is far from easy.

In general terms, it is also important to recognise that the real price of food and feed products has fallen consistently over the last 50 years. This has not come about 'out of the blue' but from enormous improvements in productivity by producers. These productivity improvements have arisen from the adoption of new technologies and techniques.

Against this background, **Brookes & Barfoot (2009)** point out the extent of use of biotech adoption globally shows that:

- For soybeans the majority of both global production and trade is accounted for by biotech production;
- For maize, cotton and canola, whilst the majority of global production is still conventional, the majority of globally traded produce contains materials derived from biotech production.

This means for a crop such as soybeans, that biotech production now effectively influences and sets the baseline price for commodity traded soybeans and derivatives on a global basis. Given that biotech soybean varieties have provided significant cost savings and farm income gains (eg, \$2.76 billion in 2007) to growers, it is likely that some of the benefits of the cost saving will have been passed on down the supply chain in the form of lower real prices for commodity traded soybeans. Thus, the current baseline price for all soybeans, including conventional soy is probably at a lower real level than it would otherwise (in the absence of adoption of the technology) have been. A similar process of 'transfer' of some of the farm income benefits of using biotechnology in the other three crops has also probably occurred, although to a lesser extent because of the lower biotech penetration of global production and trade in these crops.

Building on this theme, some (limited) economic analysis has been undertaken to estimate the impact of biotechnology on global prices of soybeans.

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**Moschini et al (2000)** estimated that by 2000 the influence of biotech soybean technology on world prices of soybeans had been between -0.5% and -1%, and that as adoption levels increased this could increase up to -6% (if all global production was biotech).

**Qaim & Traxler (2002 & 2005)** estimated the impact of GM HT soybean technology adoption on global soybean prices to have been -1.9% by 2001. Based on this analysis, they estimated that by 2005 it was likely that the world price of soybeans may have been lower by between 2% and 6% than it might otherwise have been in the absence of biotechnology. This benefit will have been dissipated through the post farm gate supply chain, with some of the gains having been passed onto consumers in the form of lower real prices.

In relation to the global cotton market, analysis by **Frisvold G et al (2007)** estimated that as a result of higher yields and production of cotton associated with the use of GM IR cotton in the US and China (in 2001), the world price of cotton lint was 0.014\$/pound lower (-3.4%) than it would have otherwise have been (based on an indicative world farm level price in 2001 for cotton lint of about \$900/tonne, this is equal to a \$30.87/tonne of lint). Important impacts arising from this (and which are equally applicable to the impact of all GM and other (non GM) cost reducing/productivity enhancing technology) are:

- Purchasers of cotton on global markets benefit from the lower prices, as do end consumers;
- Non adopting cotton farmers, both in the countries where the new (GM IR) technology is used, and in other countries where the technology is not available, lose out because they experience the lower world prices, yet get no cost savings/productivity gains that might be derived from using the new technology.

**Anderson K et al (2006)** examined the impact of the adoption of GM IR cotton up to 2001 (also simulated impacts of adoption/non adoption of the technology in a number of (then) non adopting countries) on the international cotton market. At that time (2001) they estimated that global cotton production had not been significantly affected, although the world price of cotton was estimated to be about 2.5% lower than it would otherwise have been if the technology had not been adopted in the US, China, Australia and South Africa.

### Relevant references in full

Anderson K et al (2006) Recent and prospective adoption of GM cotton: a global CGE analysis of economic impacts, World Bank Policy Research Working Paper 3917, World Bank, <http://econ.worldbank.org>

Brookes G & Barfoot P (2009) GM crops: global socio-economic and environmental impacts 1996-2007. PG Economics. [www.pgeconomics.co.uk](http://www.pgeconomics.co.uk) Also Global impact of biotech crops: income and production effects 1996-2007, Agbioforum (2009) forthcoming

Frisvold G et al (2007) Bt cotton adoption in the US and China: international trade and welfare effects, Agbioforum, vol 9, 2, 1-17

Moshini G et al (2000) Roundup Ready soybeans and welfare effects in the soybean complex, Agribusiness 16, (1): 33-55

Qaim M & Traxler G (2002) Roundup Ready soybeans in Argentina: farm level, environmental and welfare effects, 6<sup>th</sup> ICABR conference, Ravello, Italy

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Qaim M & Traxler G (2005) Roundup Ready soybeans in Argentina: farm level & aggregate welfare effects, *Agricultural Economics* 32 (1) 73-86

### ***2.3 Adoption of biotech traits and size of farm***

In relation to the nature and size of biotech crop adopters, there is fairly clear evidence that size of farm has not been a factor affecting use of the technology. Technology adoption has been by both large and small farmers, with size of operation not having been a barrier to adoption. In 2007, 12 million farmers were using the technology globally, 90% plus of which were resource-poor farmers in developing countries. Specific examples of research that have examined this issue include:

- **Fernandez-Cornejo & McBride (2000)** examined the effect of size on adoption of biotech crops in the US (using 1998 data). The a priori hypothesis used for the analysis was that the nature of the technology embodied in a variable input like seed (which is completely divisible and not a 'lumpy' input like machinery) should show that adoption of biotech crops is not related to size. The analysis found that mean adoption rates appeared to increase with size of operation for herbicide tolerant crops (soybeans and maize) up to 50 hectares in size and then were fairly stable, whilst for GM IR maize adoption appeared to increase with size. This analysis did, however not take into account other factors affecting adoption such as education, awareness of new technology and willingness to adopt, income, access to credit and whether a farm was full or part time – all these are considered to affect adoption yet are also often correlated to size of farm. Overall, the study suggested that farm size has not been an important factor influencing adoption of biotech crops;
- **Brookes (2003)** identified in Spain that the average size of farmer adopting GM IR maize was 50 hectares and that many were much smaller than this (under 20 hectares). Size was not therefore considered to be an important factor affecting adoption, with many small farmers (small in the context of average farm size in Spain) using the technology;
- **Brookes (2005)** also identified in Romania that the size of farm was not an important factor in the adoption of HT soybeans. Both large and smaller farms (within the context of the structure of production in Romania), within a range of 30 hectares to 20,000 hectares in size using the technology;
- **Pray et al (2002) and Huang et al (2002)**. This research into GM IR cotton adoption in China illustrated that adoption has been by mostly small farmers (the average cotton grower in China plants between 0.3 and 0.5 ha of cotton). They also identified that the smallest farmers experienced the largest yield gains;
- Adopters of insect resistant cotton and maize in South Africa have been drawn from both large and small farmers (see **Morse et al 2004, Ismael et al 2002, Gouse (2006)**);
- In 2007, there were 3.8 million farmers growing GM IR cotton in India, with an average size of about 1.6 hectares (**Manjunath T (2008)**);

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- GM IR technology (in cotton) is scale neutral, in that both small and larger farms adopt (**Qaim et al 2006**);
- **Penna J & Lema D (2001)** indicate that farm size has not affected the adoption of GM HT soybeans in Argentina. In fact, these analysts perceive that the availability of GM HT technology and its facilitating role in the adoption of no tillage production systems has helped small and medium sized in Argentina to improve their competitiveness. Previously these farmers used rotation and mixed farming to maintain/restore soil nutrient levels, soil structure and levels of organic matter (necessary to maintain crop yields), but the option of using GM HT soybeans in no tillage production systems had allowed these farmers to implement crop after crop production systems (eg, continuous soybeans or a corn-soybean rotation) and allow the wider implementation of second crop soybeans (after a wheat crop in the same season). These options greatly improved profitability levels, keeping them in farming rather than leaving the sector. **Bindraban P et al (2009)** also concur with this view – in their analysis of the increasing scale of soybean production systems in Brazil and Argentina over the last ten years, they conclude that this trend (of increasing size of farm) was largely driven by the need to benefit from economies of scale required to export in bulk at competitive prices and that the availability of large areas of land, suitable machinery and appropriate farm management techniques facilitated the expansion of large scale soy production systems and farms. GM HT soybean production based on no tillage, fitted with this enlargement in the scale of production but was considered to have not been a major contributor to the changes in the scale/size of soy producing farms (ie, the changes in scale/size would have probably occurred without the availability of GM HT soybeans).

Nevertheless some studies (eg, **Thirle et al (2003)** relating to GM IR cotton in South Africa) and **Qaim & De Janvry (2003)** relating to GM IR cotton in Argentina) have identified cases where small farmers have not adopted biotech traits (notably relating to GM IR cotton in South Africa) and this has been mostly attributed to lack of access to credit to buy (the more expensive) seed. In such cases, this reflects a failure in the credit market, which needs to be addressed through policy mechanisms. This is an issue of relevance for accessing all new (more expensive) technology in agriculture and is not, therefore, a GM trait-specific issue.

### Relevant references in full

Brookes G (2003) The farm level impact of using Bt maize in Spain, ICABR conference paper 2003, Ravello, Italy. Also on [www.pgeconomics.co.uk](http://www.pgeconomics.co.uk)

Brookes G (2005) The farm level impact of using Roundup Ready soybeans in Romania. Agbioforum Vol 8, No 4. [www.agbioforum.org](http://www.agbioforum.org)

Bundrabin P et al (2009) GM-related sustainability: agro-ecological impact, risks and opportunities of soy production in Argentina and Brazil, Plant Research International BV, Wageningen, Netherlands.

Fernandez-Cornejo J & McBride W (2000) Genetically engineered crops for pest management in US agriculture: farm level benefits, USDA, ERS Agricultural Economics Report No 786

Gouse M et al (2006) Output & labour effect of GM maize and minimum tillage in a communal area of Kwazulu-Natal, Journal of Development Perspectives 2:2



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Huang et al (2002) Transgenic varieties and productivity of smallholder cotton farmers in China, *Australian Journal of Agricultural and Resource Economics* 46 (3): 367-387

Ismael Y et al (2002) A case study of smallholder farmers in the Mahathini flats, South Africa, ICABR conference, Ravello Italy 2002

Manjunath T (2008) Bt cotton in India: remarkable adoption and benefits, Foundation for Biotech Awareness and Education, India. [www.fbae.org](http://www.fbae.org)

Morse S et al (2004) Why Bt cotton pays for small-scale producers in South Africa, *Nature Biotechnology* 22 (4) 379-380

Penna J & Lema D (2001) Adoption of herbicide resistant soybeans in Argentina: an economic analysis, INTA, Argentina

Pray C et al (2002) Five years of Bt cotton in China – the benefits continue, *The Plant Journal* 2002, 31 (4) 423-430. Also, Pray et al (2001) Impact of Bt cotton in China, *World Development* 29 (5), 813-825

Qaim M et al (2006) Adoption of Bt cotton and impact variability: insights from India, *Review of Agricultural Economics*, vol 28, No 1, 48-58

Qaim M & De Janvry A (2003) GM crops, corporate pricing strategies and farmers adoption: the case of Bt cotton in Argentina, *American Journal of Agricultural Economics*, 85 (4): 814-828

Thirtle C et al (2003) Can GM technologies help the poor? The impact of Bt cotton in Makhathini Flats, KwaZulu-Natal, *World Development* 31 (4): 717-732

### ***2.4 Impact on labour use***

**Qaim M et al (2006)** identified in India, associated with the adoption of GM IR cotton, that reduced insecticide sprays resulted in a lower requirement for labour to undertake pest scouting and spraying (this mostly affected male family members) but this was counterbalanced by additional labour requirements for harvesting (higher yields), with the latter labour change mainly affecting casual, usually female labour. Overall, they concluded that the net effect on labour use was neither positive or negative.

These impacts were also identified by **Dev S & Rao N (2007)**, albeit in a study focusing on the Andhra Pradesh region of India only. Their work identified that the net impact on labour use of using GM IR cotton was positive (ie, the extra harvest labour requirement was greater than the loss of pest scouting and spraying labour requirement).

**Subramanian A & Qaim M (2008)** looked at this issue further through research into a small cotton growing community in India, via monitoring of household expenditure patterns and activities. Whilst this was only a small piece of research it provided a useful insight into wider economic impacts and was representative of semi arid tropical regions in central and southern India. Its key findings were that GM IR cotton had delivered a net creation of rural employment, with the additional harvest labour requirements being greater than the reductions associated with pest scouting and spraying. This did have gender implications given that it has been mostly females who gained, relative to males who lost out. Their analysis, however shows that on average, the saved male family labour has been/can be re-

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employed efficiently in alternative agricultural and non agricultural activities so that, the overall returns to male labour increase.

The returns to management time saved for famers/farm workers and their re-deployment also tended to be greater for larger farmers than smaller ones. This was largely explained by the fact that large farmers are often better educated and have better access to financial resources which help them gain alternative employment or set up self employment activities.

**Fernandez-Cornejo J & Caswell M (2006)** showed that the adoption of GM HT soybeans in the US, by reducing management time associated with the crop, allowed additional time for off-farm income earning opportunities.

**Gouse M et al (2006)** found that the use of GM IR technology in maize (in the Kwazulu-Natal region of South Africa, in 2003/04 was neutral in respect of labour use (a year of low pest pressure). They perceive that in years of higher pest pressure the labour requirement would likely fall, as less insecticide granules would be applied by farmers/workers.

**Trigo E & Cap E (2006)**, looking at the social changes associated with the expansion of soybean production, using GM HT technology and its facilitation of no tillage production practices, cite statistics on farm employment trends between 1993 and 2005, which show that the total number of jobs in the sector has been consistent (1.2-1.3 million) during a period in which the country's unemployment rate reached its highest historic level.

### **Relevant references in full**

Dev S & Rao N (2007) Socio economic impact of Bt cotton, Centre for Economic and Social Studies, Hyderabad, Monograph, Nov 2007

Fernandez-Cornejo J & Caswell M (2006) The first decade of genetically engineered crops in the US. Economic Information Bulletin 11. Washington DC, Economic Research Service, USDA

Gouse M et al (2006) Output & labour effect of GM maize and minimum tillage in a communal area of Kwazulu-Natal, Journal of Development Perspectives 2:2

Qaim M et al (2006) Adoption of Bt cotton and impact variability: insights from India, Review of Agricultural Economics, vol 28, No 1, 48-58

Subramanian A & Qaim M (2008) Village-wide effects of agricultural biotechnology: the case of Bt cotton in India, World Development, vol 37, N0 1, 256-262

Trigo E & Cap E (2006) Ten years of GM crops in Argentine agriculture, ArgenBio, Argentina

## **2.5 Health and safety**

There is a growing body of evidence to show that the adoption of GM IR maize has delivered important improvements in grain quality from significant reductions in the levels of mycotoxins found in the grain. Several papers quantifying and measuring this, in the EU, are summarised in **Brookes G (2008)**. In terms of revenue from sales of corn, however, no premia for delivering product with lower levels of mycotoxins

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have, to date, been reported although where the adoption of the technology has resulted in reduced frequency of crops failing to meet maximum permissible fumonisin levels in grain maize (eg, in Spain), this delivers an important economic gain to farmers selling their grain to the food using sector. GM IR corn farmers in the Philippines have also obtained price premia of 10% (see **Yorobe J (2004)**) relative to conventional corn because of better quality, less damage to cobs and lower levels of impurities.

Improved health and safety for farmers and farm workers (from reduced handling and use of insecticides) is also a feature highlighted in several papers examining the impact of GM IR cotton in developing countries. **Huang et al (2002 & 2003)** and **Pray et al (2001 & 2002)** identified benefits from reduced exposure to insecticides and associated incidences of pesticide poisonings being reported in China as a result of the adoption of GM IR cotton.

**Bennett, Morse and Ismael (2006)** suggested that the number of accidental pesticide poisonings cases associated with growing cotton in South Africa had fallen following the adoption of GM IR cotton.

### Relevant references in full

Bennett R, Morse S & Ismael Y (2006) The economic impact of genetically modified cotton on South African smallholders: yields, profit and health effects, *Journal of Development Studies*, 42 (4): 662-677

Brookes G (2008) The benefits of adopting GM insect resistant (Bt) maize in the EU: first results from 1998-2006, *International Journal of Biotechnology* (2008) vol 10, 2/3, pages 148-166

Huang J et al (2002) Transgenic varieties and productivity of smallholder cotton farmers in China, *Australian Journal of Agricultural and Resource Economics* 46 (3): 367-387

Huang J et al (2003) Biotechnology as an alternative to chemical pesticides: a case study of Bt cotton in China, *Agricultural Economics* 29 (1), 55-67

Pray C et al (2002) Five years of Bt cotton in China – the benefits continue, *The Plant Journal* 2002, 31 (4) 423-430. Also, Pray et al (2001) Impact of Bt cotton in China, *World Development* 29 (5), 813-825

Yorobe J (2004) Economics impact of Bt corn in the Philippines. Paper presented to the 45<sup>th</sup> PAEDA Convention, Querzon City

### ***2.6 Impact on seed variety availability/biodiversity***

**Zilberman et al (2007)** examined whether the introduction of biotech traits may lead to a loss of seed (bio)diversity and a reduction in the number of varieties grown. They identified that the introduction of biotech traits may actually increase the number of distinct varieties when the technological, economic and regulatory conditions facilitate the adoption of biotech traits in a large number of local varieties. However, limited capacity to modify local varieties may adversely affect seed (bio)diversity, as it may result in a small number of varieties containing biotech traits (sometimes imported) being planted on land where a larger number of local varieties had formerly grown. In the seed markets of most countries, the decisions about adoption of different varieties by farmers and the availability of different seed varieties containing various traits/attributes by the local seed sector are made on economic grounds. It is therefore in the interests of biotech trait 'holders' to facilitate access to their traits by companies that breed and supply local varieties, best suited to local conditions, if they wish to maximise uptake of their technology at the farm level. However, when there are a large number of local varieties grown with

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small shares of the total market, supplied by a large number of seed companies, it may prove unattractive (from an economic perspective) to licence biotech traits to many (small) local seed companies. Therefore, if it is considered to be desirable from a public policy perspective to maintain/preserve local varieties, Zilberman et al argue it may be appropriate for the public sector to address this 'market failure' through a) operating policies and regulations that provide favourable conditions to introduce biotech traits into local varieties (ie, an efficient, transparent and low cost regulatory approval process so as to maximise the market incentives for trait availability in local seed), and b) providing incentives for farmers to continue to use local varieties without a biotech trait. In this way, partial adoption of biotech traits will occur, allowing farmers to gain access to new technology and helping to preserve seed (bio)diversity.

**Pehu F & Ragasa C (2007)** concluded that the quick and extensive adoption of GM IR cotton in China owed much to publicly developed GM IR cotton varieties and to a decentralised breeding system, which transferred quickly the GM trait to local varieties that could then be sold at relatively low prices. Similarly, in Mexico good availability of seed and credit facilitated a high adoption rate for GM IR cotton. In contrast, lack of credit and access to credit in South Africa was considered as an important factor hindered adoption.

### **Relevant references in full**

Pehu F & Ragusa C (2007) *Agricultural Biotechnology: transgenics in agriculture and their implications for developing countries*, World Bank, Background Paper for the World Development Report of 2008

Zilberman D et al (2007) *The impact of agricultural biotechnology on yields, risks and biodiversity in low income countries*, *Journal of Development Studies*, vol 43, 1, 63-78, Jan 2007

## **2.7 Risk management**

GM insect resistant technology has been cited in several of the studies examining the 'first round' effects (impacts on yields, costs and profitability) as delivering improved risk management. Essentially, the technology takes away much of the worry of significant pest damage occurring and is, therefore, highly valued (see for example, **Brookes (2003)**, **Wu F (2006)**).

This importance to risk management has also been recognised in the US, where (piloted in 2008 and more widely operational from 2009), US farmers using stacked corn traits (containing insect resistance and herbicide tolerant traits) are being offered discounts on crop insurance premiums equal to \$7.41/hectare (**Brookes G & Barfoot P (2009)**).

**Zilberman et al (2007)** argue that the reduction of production risk associated with the adoption of GM insect resistant technology is especially beneficial to smaller farmers who tend to have fewer options than larger farmers to reduce their vulnerability to risk.

### **Relevant references in full**

Brookes G (2003) *The farm level impact of using Bt maize in Spain*, ICABR conference paper 2003, Ravello, Italy. Also on [www.pgeconomics.co.uk](http://www.pgeconomics.co.uk)

Brookes G & Barfoot P (2009) *GM crops: global socio-economic and environmental impacts 1996-2007*. [www.pgeconomics.co.uk](http://www.pgeconomics.co.uk). Also see (forthcoming) *Global impact of biotech crops: income and production effects 1996-2007* in *AgBioforum*. [www.agbioforum.org](http://www.agbioforum.org)

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Wu F (2006) Mycotoxin reduction in Bt corn: potential economic, health and regulatory impacts, *Transgenic research* 15 (3): 277-289

Zilberman D et al (2007) The impact of agricultural biotechnology on yields, risks and biodiversity in low income countries, *Journal of Development Studies*, vol 43, 1, 63-78, Jan 2007

### **2.8 Impact on household incomes & food security**

These impacts have been examined in few papers to date. **Gouse et al (2005 & 2006)** examining the impact of the adoption of GM IR maize in South Africa found that the poorest farmers gained most from the higher yields associated with GM IR (white) maize adoption because the extra production replaced maize meal that had previously been bought in to meet family food requirements. In other words, home grinding and consumption of the additional production substituted for more expensive bought-in maize meal.

**Gonzales (2006)** examined in relation to the adoption of GM IR maize in the Philippines, the concept of the subsistence carrying capacity, which is defined as the minimum net farm income/profit required to cover the costs of providing a nutritional calorie intake of 2,000 kilocalories per person, per day. Based on analysis of data from farm level surveys conducted in 2003 and 2004, he found that the adoption of GM IR maize significantly improved the subsistence level carrying capacity of adopters (an average of a 66% improvement, within a range of +399% for low yielding farms and +47% for high yielding farms).

**Wang G et al (2008)** examined the impact of the adoption of GM IR cotton on farmers livelihoods in the Hebei Province of China in 2002 and 2003, and concluded that as a result of the increases in farm income, arising from higher yields, household incomes rose significantly (the income from cotton in one season was estimated to be twice the combined value of wheat and corn crops for two seasons). This higher income then played an important role in additional investment in family education, leisure and healthcare.

#### **Relevant references in full**

Gonzales D (2005) *Harnessing the benefits of biotechnology: the case of Bt corn in the Philippines*. ISBN 971-91904-6-9. Strive Foundation, Laguna, Philippines

Gouse M et al (2005) A GM subsistence crop in Africa: the case of Bt white maize in S Africa, *International Journal Biotechnology*, Vol 7, No1/2/3 2005

Gouse M et al (2006) Three seasons of subsistence insect-resistant maize in South Africa: have smallholders benefited?, *Agbioforum* 9, 1, 1-8

Wang G et al (2008) Impact of cotton on farmer livelihood system in China, ISSCRI conference 'Rationales and evolutions of cotton policies', Montpellier, France

### **2.9 Impact on income distribution**

Critics of GM crops sometimes contend that the introduction of GM technology contributes to wider income disparity between richer and poorer farmers because richer farmers are better able to afford the more expensive seed (as well as other inputs such as fertiliser and irrigation) and hence benefit more from

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the technology than their poorer counterparts. Whilst this issue applies equally to any new (more expensive) technology used in agriculture, it has been specifically examined in very few papers relating to the adoption of GM technology. **Morse et al (2007)** examined this issue in relation to the adoption of GM IR cotton in India (Maharashtra State in 2002 and 2003). Their findings were that income disparities between adopters and non adopters did increase (because of the income benefits from using the technology), however, income disparities between adopters narrowed. Hence, the adoption of the technology both widened some disparities, yet narrowed others. The possible reasons cited for the narrowing of this disparity between adopters include a possible greater uniformity of skills between adopting farmers, and the role of the technology in simplifying pest control management – farmers no longer needed to scout their crops so much for pest levels and were having to, therefore, make fewer decisions on which insecticides to spray, when to apply, how much to use and how to apply. In effect, the GM IR technology contributed to reducing risks of pest damage uniformly for farmers where previously the pest damage levels were more affected by farmer skills in managing pests through the use of insecticides.

### Relevant references in full

Morse S et al (2007) Inequality and GM crops: a case study of Bt cotton in India: *Agbioforum* Vol 10, 1,

### **2.10 Wider economy impacts**

In Argentina, agricultural exports contribute to government tax revenues (since 2002). **Trigo and Cap (2006)** estimated, that export taxes on soybean exports between 2002 and 2005 amounted to \$6.1 billion, of which \$2.6 billion can be attributed to the increase in production linked to the release of GM HT soybean varieties.

### Relevant references in full

Trigo E & Cap E (2006) Ten years of GM crops in Argentine agriculture, *ArgenBio*, Argentina

## **Appendix 1: Other relevant references – literature reviews which cite and draw on many of the original studies**

Food and Agriculture Organisation of the United Nations (FAO) (2004): *The state of food and agriculture 2003-04: agricultural biotechnology meeting the needs of the poor?*, FAO, Rome

Organisation for Economic Co-operation and Development (OECD) (2000) *Modern biotechnology and agricultural markets: a discussion of selected issues*: OECD, Committee of Agriculture, Paris, France

Raney T (2006) Economic impact of transgenic crops in developing countries, *Current Opinion in Biotechnology*, 17 (2) 174-178

Smale M et al (2009) Measuring the economic impacts of transgenic crops in developing countries during the first decade: approaches, findings and future directions, *Food Policy Review No 10*, International Food Policy Research Institute (IFPRI), Washington, USA