PG Economics Limited

Focus on yield

Biotech crops: evidence, outcomes and impacts 1996-2006

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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 (1996-2006), this brief focuses on yield effects, as detailed in the peer review scientific journal article "Global impact of biotech crops: socio-economic and environmental effects 1996-2006[1]" by Graham Brookes and Peter Barfoot.

PG Economics Ltd, is a U.K.-based independent consultancy that 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

Positive yield and production impacts

Since 1996, biotech crops have added important volumes to global production of corn, cotton, canola and soybeans (Table 1).

Production of the four crops, on the 100 million hectares planted to biotech crops in 2006, were significantly higher than levels would have otherwise been if biotechnology had not been used by farmers (Table 1). Incremental yields ranged from 3 percent for canola to 20 percent for soybeans.

The biotech IR traits have targeted major pests of corn and cotton crops. These pests, persistent in many parts of the world, significantly reduce yield and crop quality, unless crop protection practices are employed. The biotech IR traits have delivered positive yield impacts in all user countries (except Australia[2]) when compared to average yields derived from crops using conventional technology (such as application of insecticides and seed treatments). Since 1996, the average yield impact across the total area planted to these traits over the 11 year period has been +5.7 percent for corn traits and +11.1 percent for cotton traits (Figure 1).

TABLE 1:

Additional crop production arising from positive yield effects of biotech crops

	1996-2006 ADDITIONAL PRODUCTION (MILLION TONNES)	2006 ADDITIONAL PRODUCTION (MILLION TONNES)	PERCENT CHANGE IN PRODUCTION 2006 ON AREA PLANTED TO BIOTECH CROPS
Soybeans	53.3	11.6	**+20%**
Corn	47.1	9.7	**+7%**
Cotton	4.9	1.4	**+15%**
Canola	3.2	0.2	**+3%**

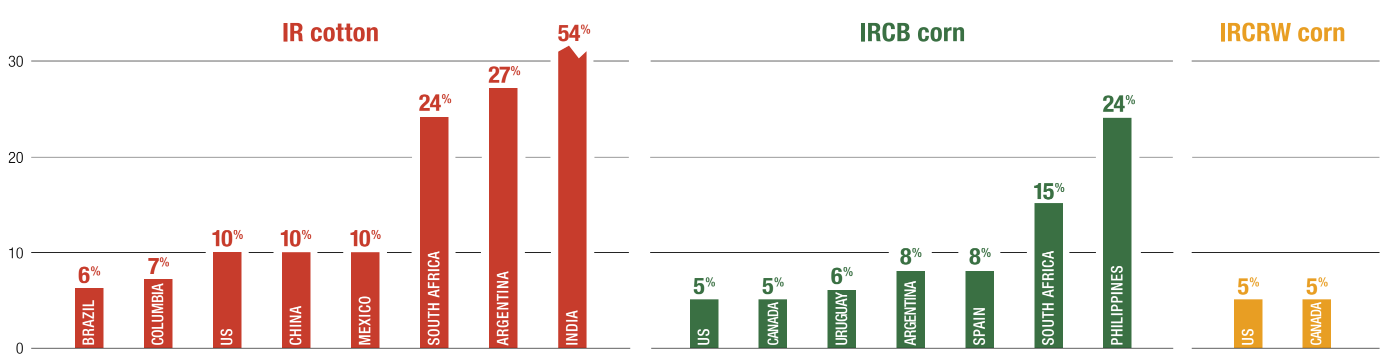
Although the primary impact of biotech herbicide tolerant (HT) technology has been to *provide more cost effective* (less expensive) and *easier* weed control, improved weed control has nevertheless occurred — delivering higher yields. In some cases, such as canola, the opportunity to improve yields from *better* weed control (relative to weed control obtained from conventional technology) is limited. In other cases, HT soybeans in Romania improved the average yield by over 30 percent and HT corn in Argentina and the Philippines delivered yield improvements of +9 percent and +15 percent, respectively.

Biotech HT soybeans have also facilitated the adoption of no-tillage production systems. In addition to conserving water, soil and energy, and reducing off-site movement of agricultural chemicals, the ability to utilize conservation tillage has shortened the production cycle and allowed double-cropping in South America. This advantage enables many farmers to plant a crop of soybeans immediately after a wheat crop in the same growing season. This second crop, additional to traditional soybean production, has added 53.1 million tonnes to soybean production in Argentina and Paraguay between 1996 and 2006.

FIGURE 1:

Average yield impact of biotech IR traits 1996-2006 by country and trait

Notes: IRCB = resistant to corn boring pests, IRCRW = resistant to corn rootworm



Improving economic well being and food security

Biotech traits have increased farmer incomes by a total of $33.8 billion (1996-2006). About half of this extra income has been earned by farmers in developing countries.

This incremental farm income, when spent on goods and services, has had a positive multiplying effect on local, regional and national economies. In developing countries, the additional income derived from biotech crops 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 more than a third.

The additional production arising from biotech crops (1996-2006) has also contributed enough energy (in kcal terms) to feed about 310 million people for a year (similar to the annual requirement of the combined populations of Indonesia and Vietnam: see appendix for assumptions and calculations). Biotech crops have also made important contributions to meeting protein and fat requirements for considerable numbers of people (Figure 2).

Environmental benefits

Biotech crop production has also resulted in important environmental benefits. Pesticide use on the four crops in the countries where biotech crops have been planted have fallen by 286 million kg (-7.9 percent), resulting in a larger, 15.4 percent reduction in the associated environmental impact[3] (Figure 3).

Greenhouse gas emission reductions have also been facilitated, equal to 14.76 billion kg of carbon dioxide (as measured in 2006), equivalent to removing 6.56 million cars from the roads for a year.

The GHG emission reductions derive from reduced fuel use (due to less frequent herbicide and insecticide applications, and a reduction in the energy use in soil cultivation). In addition, the facilitation of no- and reduced-tillage production systems by the biotech HT technology results in less ploughing and increased carbon storage in the soil. This additional carbon storage reduces carbon dioxide emissions to the environment.

FIGURE 2:

Contribution to food security from biotech crop additional production 1996-2006 (millions fed/year)

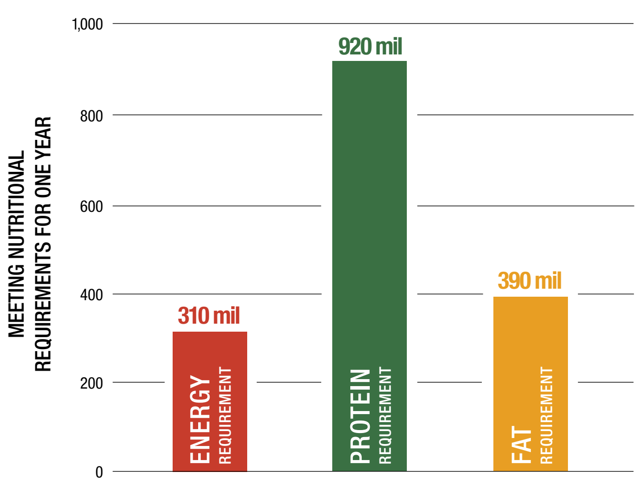
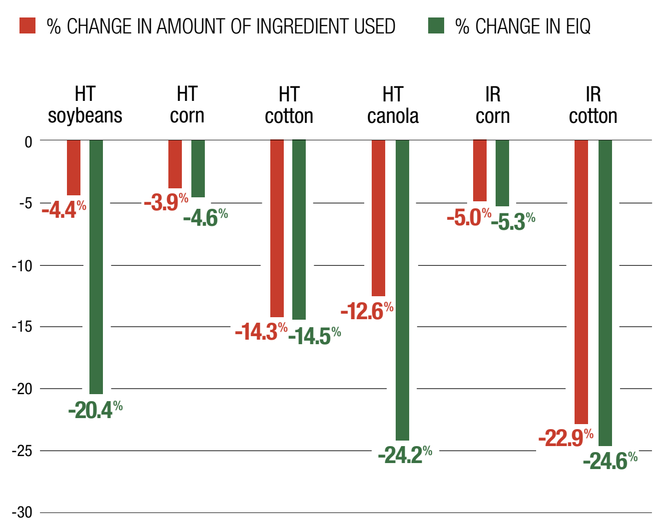


FIGURE 3:

Change in herbicide and insecticide use from biotech crops 1996-2006



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
Protein (grams)	63	50	56.5
Fat (grams)	100	78	89

Crop key nutrition composition (per kg of edible material)

	ENERGY (KCAL)	PROTEIN (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.ars.usda.gov**

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

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

Assumption on corn utilization — 99 percent usable

Assumptions for uses of crops (by percent)

	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%
Cotton seed oil	50%	0%	50%
Cotton seed meal	0%	50%	50%

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

Use of corn and oilseeds in meat production assumptions
The following simplifying assumptions were used:

- As most corn and oilseeds 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.gov/AmberWaves/February08/**). 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 1 kg 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 percent of live weight converted to meat and for pig meat assumes 35 percent conversion.
- Corn constitutes 70 percent of a typical poultry feed ration and 75 percent 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 percent in poultry feed and 20 percent 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 1 kg of pig meat (at the consumer level).

1 AgBioForum 2008 11 (1), 21-38. **www.agbioforum.org**. The full (longer) version of the report is available on **www.pgeconomics.co.uk**.

2 This reflects the levels of *Heliothis* pest control previously obtained with intensive insecticide use. The main benefit and reason for adoption of this technology in Australia has arisen from significant cost savings (on insecticides) and the associated environmental gains from reduced insecticide use.

3 As measured by the indicator, the environmental impact quotient (EIQ) – see Brookes and Barfoot (2008) for further details.

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