Agricultural Biotechnology
Delivering Benefits for Farmers, Consumers, and the Environment

Crops improved through biotechnology have been adopted by farmers in the United States and around the world at rates never before seen by any other advances in the history of agriculture. From the first significant commercial plantings in 1996, double digit growth in each subsequent year has led to more than 282 million acres of biotech crops planted in 2007 (252 million acres in 2006) in 23 countries (22 in 2006).[1] These crops are grown by 12 million farmers (10.3 million in 2006) — 11 million of whom are small-scale farmers in developing countries (9.3 million in 2006). The reason for such impressive adoption rates is simple — agricultural biotechnology delivers significant and tangible benefits, all the way from farm to fork. Helping to provide for more sustainable agricultural production, the benefits include a reduction in the environmental impacts of agriculture, increased production on the same amount of acreage, improved food quality, and increased farmer incomes.

Environmental Benefits: Enhanced Sustainability and Reduced Environmental Footprint

Agricultural biotechnology has helped enable large shifts in agronomic practices that have led to significant and widespread environmental benefits. No-till agriculture,[2] in limited use prior to 1996, has been widely adopted due to the superior weed control from biotech crops that are able to tolerate the newer class of lower-impact herbicides. This has led to improved soil health and water retention, reduced runoff, and reduced greenhouse gas emissions from agriculture. Peer-reviewed scientific studies have repeatedly found biotech varieties to be much friendlier to the environment, more sustainable than conventional counterparts, and far more economical and productive than organic.

No-Till Agriculture

Farmers have found that the use of biotech crops can reduce the need for plowing to control weeds. This leads to better conservation of soil and water and a decrease in soil erosion and soil compaction. No-till agriculture has enabled farmers to shift to more effective, simpler weed control regimes through which numerous more specialized herbicides have been replaced by a smaller number of broad spectrum compounds with reduced environmental impacts, as in Figure 1 below. In terms of Environmental Quality Index (EQI) calculations and volume of active ingredient, global use of herbicides has declined since the introduction of biotech crops.[3]

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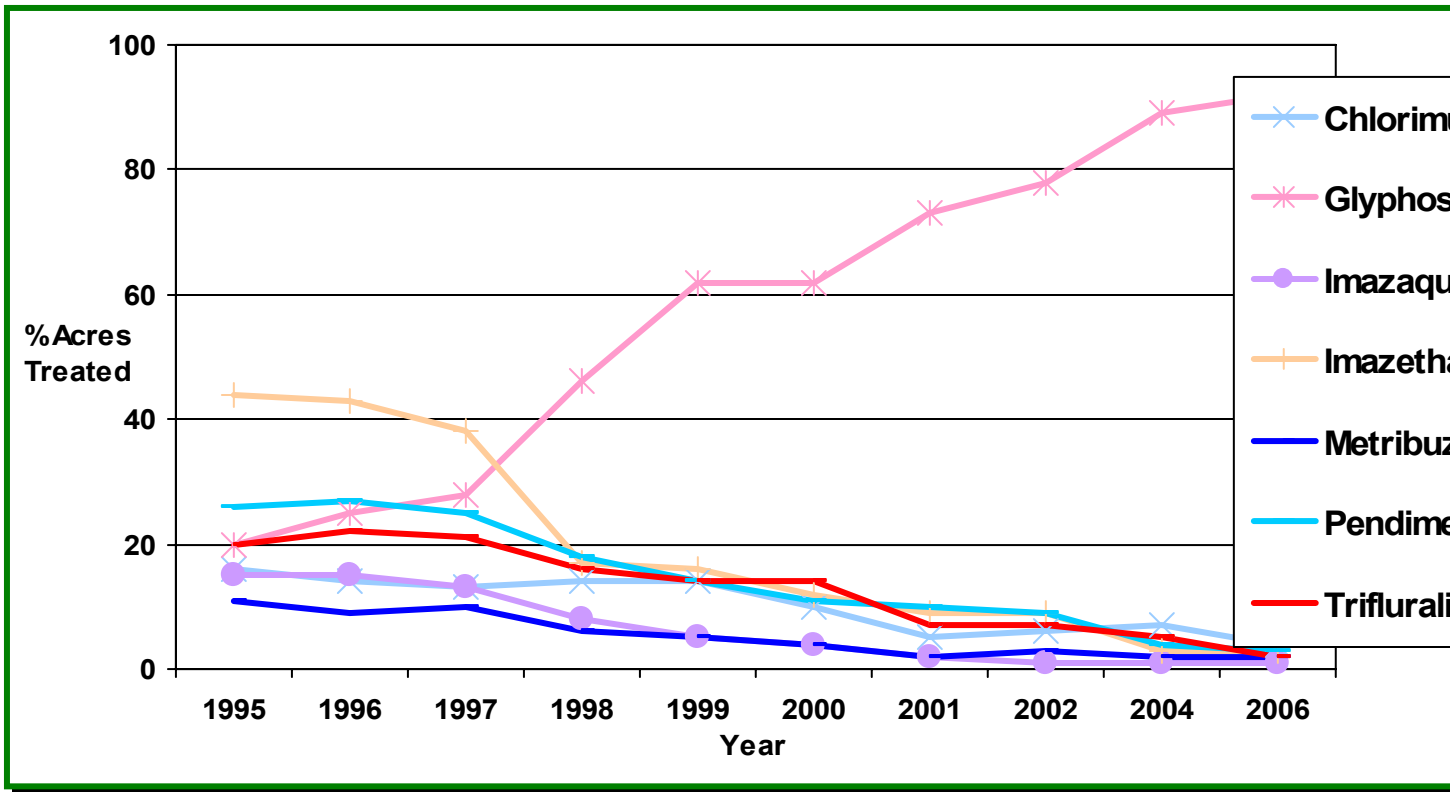
[1] James, Clive. February 2008. *Global Status of Commercialized Biotech/GM Crops: 2007*. International Service for the Acquisition of Agri-Biotech Applications (ISAAA).

[2] No-till agriculture seeks to conserve topsoil and moisture while reducing erosion by avoiding the use of plowing for weed control.

[3] Brookes, Graham, & Peter Barfoot. 2006. *Global Impact of Biotech Crops: Socio-Economic and Environmental Effects in the First Ten Years of Commercial Use*. PG Economics/ISAAA Brief 36-2006.

A reduction in plowing has also enabled farmers to significantly reduce the consumption of fuel and decrease greenhouse gas emissions. Studies show that biotech crops have saved farmers 441 million gallons of fuel through reduced fuel operations — which has resulted in eliminating nearly 10.2 million pounds of carbon dioxide emissions since 1996. This is equivalent to removing four millions cars from the road in one year (which is about 17 percent of all registered cars in Great Britain).[4] Crops improved through biotechnology have thus had a significant impact improving sustainability and reducing the environmental impacts associated with agricultural production[5].

Figure 1. Herbicide use in Soybeans. (data courtesy of Leonard Gianessi, Crop Protection Research Institute).



[4] Brookes, Graham, & Peter Barfoot. 2006.

[5] Kovach, J., C. Petzoldt, J. Degni, and J. Tette. 1992. A method to measure the environmental impact of pesticides. New York's Food & Life Sciences Bulletin. NYS Agricul.Exp. Station, Cornell University, Geneva, NY, 139. 8pp. updated annually at http://www.nysipm.cornell.edu/publications/EIQ.html.

Improved Pest Control

Biotechnology has made possible pest control measures that are more precisely targeted at specific problem pests while dramatically reducing impacts on non-target species. Biotech varieties have dramatically reduced farmers' reliance on pesticide applications, eliminating 69.7 million pounds of pesticide applications in the United States in 2005.[6] Globally it is estimated that pesticide applications decreased six percent in the interval from 1996-2004, eliminating 379 million pounds of pesticide applications.[7]

Some biotech opponents have warned of the potential emergence of so-called "superweeds," combining herbicide-resistant characteristics of different biotech crops. These "superweeds" would supposedly grow out of control and be resistant to weed killers. However, in documented cases where a herbicide-resistance gene has moved into a weed species, the weeds have not become widespread because they remain controllable with many other herbicides and a variety of intercropping and cultivation techniques. Far from being unique, or even particularly problematic with biotech crops, this is a well known phenomenon that farmers have a long history of managing successfully. Herbicide-tolerance is widespread in plants, and pre-dates the use of biotechnology. This explains why so many different herbicides are used to control different weeds, and overall, biotechnology has played a significant role in decreasing pesticide and herbicide applications.

Studies conclusively show that biotechnology is also benefiting biodiversity in numerous ways. No-till agriculture sustains soil health, and helps the conservation of topsoil and moisture content.[8] These practices, coupled with reduced pesticide applications have played a significant role in encouraging the growth of habitats that support different varieties of wildlife. Studies have shown that songbirds have actually returned to agricultural fields in increasing numbers as biotech crop acreage has increased.[9]

Farmer Benefits: Increased Production and Income

The phenomenal acceptance rate of biotech crops is testament alone to the significant benefits seen by farmers worldwide — with all the modern farming choices available today, if biotech crops did not deliver benefits to farmers, they would not be adopting this technology at unprecedented and exponential rates around the world. Farmers who once plant biotech seed typically repurchase at rates well above 90 percent.

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[6] Sankula, Sujatha. November 2006. *Quantification of the Impacts on U.S. Agriculture of Biotechnology-Derived Crops Planted in 2005*. National Center for Food and Agricultural Policy.
[7] Brookes, Graham and Peter Barfoot. 2005. *GM Crops: The Global Economic and Environmental Impact — The First Nine Years 1996-2004*. AgBioForum 8 (2&3): 187-196.
[8] American Soybean Association. 2001. *ASA Study Confirms Environmental Benefits of Biotech Soybeans*.
[9] Byford, Jim. 2002. *GMO Systesm Good for Wildlife*. Southeast Farm Press.

Increased Yield

When biotech crops were initially introduced, farmers did experience some slight yield penalties; this is a reflection of the fact that conventional seed improvement continued during the five to seven years it took for the first biotech varieties to receive government regulatory approval. However, initial yield penalties were more than offset by economies in production costs, such as reduced weed control/tillage costs. These yield penalties that were initially seen upon the introduction of some biotech soybean varieties diminished over time until yields of biotech *vs*. conventional varieties are now equal to, or favor biotech varieties. In fact, the most detailed study to date indicates biotech helped increase U.S. agricultural production by 8.34 billion pounds on 123 million acres in 2005 – a yield increase for corn of 30% since 1996, and 22% in soybeans.[10]

Increased Farm Income

Because the use of biotech crops can decrease the amounts of certain inputs, biotech crops have been shown to decrease U.S. farmers' production costs by $1.4 billion in 2005, contributing to an increase in net profits of $2 billion that year. Worldwide, conservative estimates indicate biotech crops increased farmer income by $4.8-6.5 billion in 2004, part of a cumulative gain of $19-27 billion between 1996 and 2004.[11] The estimated total value of biotech crops globally is estimated at $44 billion in 2003-4.[12]

Agricultural Biotechnology in the Developing World

Perhaps what is most significant about agricultural biotechnology are the numerous benefits they can provide to developing countries and people suffering from poor agricultural productivity and the resultant hunger and starvation. According to the United Nations, worldwide more than 850 million people are malnourished. This situation is expected to worsen by 2050, when the world's population will increase by 50 percent and the world's cultivable land will decrease by 50 percent, placing new pressures on global agriculture.

While there is no easy and singular solution to starvation, we know that biotechnology can play a role in expanding and enhancing the global food supply and improving the economics of poor rural communities. Many global health organizations have acknowledged the potential of biotechnology to address food insecurity.

- In 2005, the World Health Organization's Food Safety Department found that "the application of modern biotechnology in food and agriculture has the potential to reduce some problems associated with food insecurity."[13]

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[10] Sankula, Sujatha, 2006.
[11] Brookes and Barfoot, 2005.
[12] Runge, C. Ford and Barry Ryan. 2004. *The Global Diffusion of Plant Biotechnology: International Adoption and Research in 2004.*
[13] World Health Organization, Food Safety Department. June 2005. *Modern Food Biotechnology, Human Health and Development: An Evidence-Based Study*.

- The United Nations (UN) Food and Agriculture Organization stated in 2004 that "biotechnology can contribute to meeting the challenges" faced by poor farmers and developing countries. UN officials indicated that agricultural biotechnology is a complementary tool to traditional farming methods that can help poor farmers and consumers, and improve food security.[14]

Consumer Benefits of Agricultural Biotechnology

Biotech crops have improved quality of food and feed by decreasing the amount of foreign material (*e.g.,* weed residues) in harvests, and by reducing the amount of insect damage to harvested crops. For example, biotech cotton fibers are less likely to be insect damaged, and biotech corn is significantly less susceptible to fungal disease[15] and has substantially lower levels of cancer-causing compounds such as aflatoxin, fumonisin and other mycotoxins.[16]

Sometimes, biotech crops are actually safer than conventional or organic crops. The studies cited found that biotech corn contains substantially lower levels of cancer-causing compounds and of the mycotoxins linked to cases of spina bifida.

As agricultural demands continue to increase, many environmentally valuable ecosystems such as rainforests are being converted to farmland. Agricultural biotechnology can increase yields on existing farmlands, which decreases the pressure from increased demand to convert more wild lands to agriculture. Additionally, biotech traits in the future—such as drought-tolerance, varieties that are tolerant of salty or toxic soils or freezing temperatures—will allow farmers to bring traditionally non-arable lands into production.

Future of Agricultural Biotechnology

Researchers worldwide are continually working to develop new biotech varieties of plants, crops and trees that benefit farmers, industry, consumers and the environment. Some exciting new developments include:

- Plants and trees improved through biotechnology to express multiple traits, such as virus-tolerance and pest-tolerance.
- Biotech plants and trees that can tolerate or resist certain environmental stresses, such as drought or saline soil.
- Consumers will soon see biotech crops that are nutrient-enhanced and even allergen-free, and oils from biotech crops that are healthier and contain fewer saturated fats and no trans fats after processing.

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[14] United Nations Food and Agriculture Organization. April 2004. *The State of Food and Agriculture 2003-2004: Agricultural Biotechnology — Meeting the Needs of the Poor*.

[15] Munkvold, G.P., R.L. Hellmich, and W.B. Showers. 1997. *Reduced Fusarium Ear Rot and Symptomless Infection in Kernels of Maize Genetically Engineered for European Corn Borer Resistance*. *Phytopathology* 87: 1071-1077.

[16] Munkvold, G.P., R.L. Hellmich, and L.G. Rice. 1999. *Comparison of Fumonisn Concentrations in Kernels of Transgenic Bt Maize Hybrids and Non-Transgenic Hybrids. Plant Disease* 83:130-138.

- Biotechnology can now produce pharmaceutical products, as well as therapeutic proteins, antibodies, and enzymes to assist in the production of biopharmaceuticals.

Additional Resources

Environmental Benefits

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