

The Benefits of Biotechnology

Scientific Assessments of Agricultural
Biotechnology's Role in a Safer, Healthier World





Crops improved through agricultural biotechnology have been grown commercially on a commodity scale for over 12 years. These crops have been adopted worldwide at rates exceeding any other advances in the history of agriculture.

This report assesses the impact biotechnology is having on the global agriculture system from a community, health and environmental perspective.





Impact on the Global Community

Agricultural biotechnology can help solve the global food crisis and make a positive impact on world hunger. According to the United Nations, food production will have to rise by 50 percent by the year 2030 to meet the demands of a growing population.

Agricultural biotechnology has been shown to multiply crop production by seven- to tenfold in some developing countries, far beyond the production capabilities of traditional agriculture, and the global community is taking notice. In 2007, 12 million farmers in 23 countries – 12 developing and 11 industrialized – planted 252 million acres of biotech crops, primarily soybeans, corn, cotton and canola. Eleven million of these were small or resource-poor farmers in developing countries.

Farmers earn higher incomes in every country where biotech crops are grown. When farmers benefit, their communities benefit as well.

Positive Impact on Human Health

Agricultural biotechnology is moving beyond input traits and is focused on delivering consumer health benefits. The soybean crop is a good example, with over 10 new soybean varieties with human health benefits moving toward commercialization. Beneficial traits include lower saturated fat, increased omega-3 fatty acids and increased isoflavone content.

Consumers can rest assured that agricultural biotechnology is safe. These crops have been repeatedly studied and declared safe by expert panels the world over. In the 12+ years that biotech crops have been commercially grown, there has not been a single documented case of an ecosystem disrupted or a person made ill by these foods.

Impact on the Environment

Arguably, the biggest environmental impact of biotech crops has been the adoption of no-till farming. Herbicide-tolerant crops like biotech soybeans allowed farmers to almost completely eliminate plowing on their fields, resulting in better soil health and conservation, improved water retention/ decreased soil erosion and decreased herbicide runoff. In fact, no-till farming has led to a global reduction of 14.76 billion kg of carbon dioxide (CO₂) in 2006, the equivalent of removing 6.56 million cars from the roads for one year.

Global pesticide applications decreased six percent in the 10 years after biotechnology derived crops were first introduced, eliminating 379 million pounds of pesticide applications.

Biotechnology derived crops are improving water quality both through less herbicide and pesticide in runoff from fields, and in the future through reducing phosphorus excretion in livestock by using biotech derived feed that contains reduced levels of phytate.

These results show that agricultural biotechnology delivers tangible and significant benefits for farmers, consumers and the environment. These benefits add up to a more sustainable future. Consumers benefit with safe, healthy and abundant food to feed a growing population. Farmers reap the benefits of increased productivity and income that contributes to agricultural sustainability in their communities. Perhaps most importantly, biotechnology helps care for the environment by decreasing agricultural chemical applications and carbon emissions.

Biotechnology and the Global Community

Sustainable Communities

Many scientists would agree that biotechnology is an important contributor to a sustainable agriculture system because it can produce more food with a lesser environmental impact as compared to conventional agriculture. Many farm groups throughout the world are working to adopt sustainable agriculture practices.

Sustainable Agriculture Defined

Sustainable agriculture was defined by the U.S. Congress in the 1990 Farm Bill as an integrated system of plant and animal production practices having a site-specific application that will, over the long term, satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole.¹

Soybean Farmers Working Toward a Sustainable Future

U.S. soybean growers have been committed for many years to using sustainable production methods to meet the needs of the present while improving the ability of future generations to meet their own needs by:

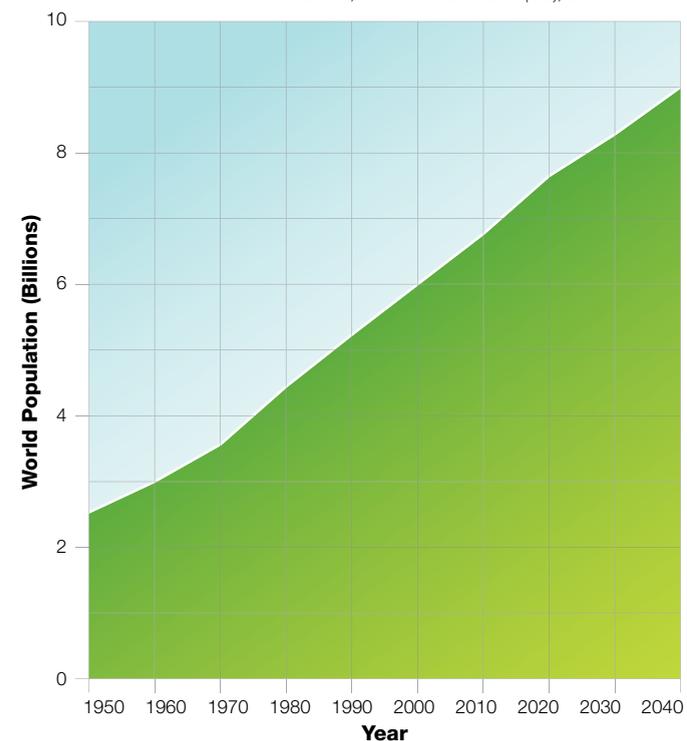
- **Adopting technology and best practices which increase productivity to meet future needs while being stewards of the environment;**
- **Improving human health through access to safe, nutritious food;**
- **Enhancing the social and economic well being of agriculture and its communities.**

The American Soybean Association and the United States Department of Agriculture published a book for U.S. soybean farmers entitled *Soybean Management and the Land: a Best Management Practices Handbook for Growers*. Among other farming practices, that handbook promoted adoption of conservation tillage practices. Concurrently (i.e. 1996-2001), U.S. farmers found that the new biotech herbicide-resistant soybeans made “no-till” and other conservation tillage practices much more feasible in more latitudes and on more of the many different farm soil types in the U.S. than ever before. During that time period, use of conservation tillage in soybean fields approximately doubled, and by 2001, 49 percent of total U.S. soybean hectares were no-till and an additional 33 percent of total U.S. soybean acres were low-till.²

Other aspects of sustainable agriculture are discussed in greater detail in the coming pages.

World Population 1950-2040

Source: U.S. Census Bureau, International Data Base (IDB), 2008



World Hunger

Biotechnology holds great promise for increasing the world's food supply and improving the quality of that food. It is estimated that 800 million people around the world suffer from chronic food shortages, and millions more could go hungry due to current and future food crises. Crops improved through biotechnology are producing higher yields worldwide to help feed a hungry and growing world.

The UN Calls for Increased Food Production

United Nations (UN) Secretary General Ban Ki-moon urged nations to seize an “historic opportunity to revitalize agriculture” as a way of tackling the food crisis. Mr. Ban told a UN-sponsored summit in June 2008 in Rome that food production would have to rise by 50 percent by the year 2030 to meet demand. The UN's Food and Agriculture Organization (FAO) has warned industrialized countries that, unless they increase yields, eliminate trade barriers and move food to where it is needed most, a global catastrophe could result.

Food prices experienced in 2008 are believed to have pushed 100 million people into hunger worldwide. And, the world population continues to increase further straining food supplies. Currently at 6.7 billion people,³ the world population increased from 3 billion in 1959 to 6 billion by 1999, and is projected to grow to 9 billion by 2040.⁴ Poorer countries are faced with a 40 percent increase in their food imports bill this year, and experts say some countries' food bills have doubled in the past year.⁵

The UN FAO acknowledges that biotechnology provides powerful tools for the sustainable development of agriculture to help meet the food needs of a growing population. At the same time, the FAO calls for a cautious, case-by-case approach to determine the benefits and risks of each individual biotech crop genetic event and to address the “legitimate concerns for the biosafety of each product and process prior to its release.”⁶



Rising Food Costs

Prices of agricultural food commodities have risen considerably during the past few years. Among the contributing factors are low levels of world stocks for some crops, below average harvests and crop failures in some places. When food prices rise, the poorest consumers are often the first to suffer.

As a result of earlier years of low food prices, investment in agriculture has declined and many poor countries are increasingly dependent on imports to meet their food needs.⁷

According to the UN FAO, this economic climate has created a serious risk that fewer people will be able to get food, especially in the developing world. The agency's food price index rose by more than 40 percent over one year, a rate more than four times higher than is considered acceptable. The total cost of food imported by the neediest countries rose 25 percent in 2007.⁸



Some Blame African Hunger on Rejection of Agricultural Biotechnology

According to the *Financial Times*, as world food prices surge and shortages loom, biotech crops are increasingly seen as a way to raise agricultural yields without using more energy or chemicals. In Europe, where agricultural biotechnology has faced the strongest public resistance, more politicians, experts and farmers' leaders are speaking out in its favor.

Sir David King, the United Kingdom (UK) government's former chief scientist, is one who says biotechnology is the only technology available to solve the world food price crisis.⁹

During a 2008 speech at the British Association's Festival of Science in Liverpool, King criticized non-governmental organizations and the UN for backing traditional farming techniques, which he insists cannot provide enough food for the African continent's growing population. "The problem is that the western world's move toward organic farming - a lifestyle choice for a community with surplus food - and against agricultural technology in general and GM in particular, has been adopted across the whole of Africa, with the exception of South Africa, with devastating consequences."¹⁰

King has also said that biotech crops could help Africa mirror the substantial increases in crop production seen in India and China. He noted that modern agricultural technologies can multiply crop production per hectare by factors of seven to 10 and that traditional techniques could "not deliver the food for the burgeoning population of Africa."¹¹

World Leaders Recognize the Benefits of Biotechnology

The G8 leaders, meeting in Hokkaido, Japan, at their annual summit in July 2008, agreed to work to increase global agricultural yields by providing farmers with greater access to seed varieties developed through biotechnology.

The G8 leaders decided to increase global agricultural yields by providing greater access to seeds developed through biotechnology. The group decided that they would "accelerate research and development and increase access to new agricultural technologies to boost agricultural production" in an effort to help address food security and poverty. In addition, they said they would "promote science-based risk analysis including on the contribution of seed varieties developed through biotechnology." They also agreed to form a global partnership on agriculture and food, which would include the governments of developing countries, the private sector, civil society groups, international donors and multilateral institutions.¹²

Growth in Biotech Plantings Helps Feed a Hungry World

In 2007, 12 million farmers in 23 countries - 12 developing and 11 industrialized - planted 252 million acres of biotech crops, primarily soybeans, corn, cotton and canola.

Eleven million of these farmers were small or resource-poor farmers in developing countries.¹³ The size of the farm has not been a factor affecting use of the technology. Both large and small farms have adopted biotech crops. For more than a decade, agricultural biotechnology has provided economic and environmental benefits.



Biotechnology Provides Farmer and Community Benefits

The world's farmers are not the only beneficiaries of agricultural biotechnology. When the farmer benefits, the local community benefits economically, and the consumers in that community also benefit with a safe, nutritious and sustainable food supply. For example, in Argentina, the economic gains resulting from a 140 percent increase in soybean area since 1995 are estimated to have contributed towards the creation of 200,000 additional agriculture-related jobs and export-led economic growth.¹⁴

Increased Production and Plantings

Since the first commercialized crop in 1996, the world's farmers have consistently increased their plantings of biotech crops by double-digit growth rates every year. The increase of 12 million hectares between 2005 and 2006 was the second highest in the last five years and equivalent to an annual growth rate of 13 percent in 2006. The global area of approved biotech crops in 2006 was 102 million hectares.¹⁵ Biotechnology helped increase U.S. agricultural production yields by 8.34 billion pounds of corn and soybeans on 123 million acres in 2005.¹⁶ Biotech plants that resist pests and diseases, tolerate harsh growing conditions and reduce spoilage prevent farmers from losing billions of pounds of important food crops annually.

Increased Farmer Income

Farmers earn higher incomes in every country where biotech crops are grown. 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 2004.¹⁷ It is noteworthy that farmers in developing countries captured the majority of the extra farm income from biotech crops. The largest gains in farm income have been in the soybean sector, largely from cost savings. For example, the \$3 billion additional income generated by herbicide-tolerant biotech soybeans in 2006 was equivalent to adding 6.7 percent to the value of the crop in the biotech-growing countries or adding the equivalent of 5.6 percent to the \$55 billion value of the global soybean crop in 2006.¹⁸

Cost Savings from Decreased Pesticide/Herbicide Use

Biotech crops decreased U.S. farmer's production costs by \$1.4 billion in 2005, contributing to an increase in net profits of \$2 billion that year.¹⁹ For soybeans specifically, farmers save an estimated \$73/hectare in reduced input costs.²⁰ Because small farms around the world are hampered by the same pests, international farming communities benefit when U.S. farmers are able to save on pesticide/herbicide costs and reinvest their funds into technology improvements. Increased productivity is a benefit to any farmer, but tremendously enhances quality of life when a small-scale farmer can escape from subsistence farming.



Biotechnology allows U.S. soybean farmers to efficiently grow corn and soybeans to feed a growing world.

Biotechnology & Human Health

The benefits of biotechnology reach far beyond environmental and farmer benefits. Consumers are already benefiting with healthier foods, and those benefits are expected to grow significantly. Consumers will soon see biotech crops that are nutrient-enhanced, and in the case of soybeans, a variety of health benefits stemming from enhanced protein and oil content. Ensuring consumer safety is paramount throughout all product introductions.

Safety

Most foods we eat today come from plants or animals that farmers have “genetically modified” through centuries of conventional breeding.²¹ Plants and animal species have been crossbred to develop useful new varieties with beneficial traits, such as better taste or increased productivity. Traditional crossbreeding also produces changes in the genetic makeup of a plant or animal. Modern agricultural biotechnology techniques are different and substantially improved from traditional crossbreeding because they allow for more precise development of crop and livestock varieties.

In the 12+ years that biotech crops have been commercially grown, there has not been a single documented case of an ecosystem disrupted or a person made ill by these foods.



Substantial Equivalence as a Measure of Safety

“Substantial equivalence” is an important concept related to the safety of biotech foods. In this method, the new plant variety is compared to its traditional counterpart because the counterpart has a history of safe use as a food. The concept of substantial equivalence effectively focuses the scientific assessment on potential differences that might present safety or nutritional concerns. Substantial equivalence provides a process to establish that the composition of the plant has not been changed in such a way as to introduce any new hazards into the food, increase the concentration of inherent toxic constituents or decrease the customary content of nutrients.

For example, high oleic acid soybean oil from biotech soybeans produces an oleic acid concentration that falls outside the range typically found in soybean oils (a change leading to a more stable oil, thus reducing or eliminating the need for hydrogenation, a process which often creates artificial trans fats). From a scientific perspective, this food is nevertheless considered safe, based on scientific knowledge about the safety of oleic acid, a common fatty acid in foods.²²

In the U.S., new foods produced through conventional breeding or introduced into the marketplace from other parts of the world where they have been widely consumed are not required to undergo exhaustive safety assessments. They are assumed to be safe because they are similar to other varieties or because they have been safely consumed elsewhere in the world. On the other hand, products derived through agricultural biotechnology are exhaustively assessed for safety before their introduction into the food marketplace.

The safety assessment of foods derived through biotechnology has actually been much more stringent than for conventionally derived products.²³



Biotechnology has been declared safe from experts across the globe.

Institute of Food Technology (IFT) Statement on Safety

The Human Food Safety Panel of the Institute of Food Technology (IFT) reviewed the available literature and concluded: "Biotechnology, broadly defined, has a long history of use in food production and processing. It represents a continuum that encompasses both centuries-old traditional breeding techniques and the latest techniques based on molecular modification of genetic material...The newer rDNA biotechnology techniques, in particular, offer the potential to rapidly and precisely improve the quantity and quality of food available."

The IFT statement continues, "Crops modified by modern molecular and cellular methods pose risks no different from those modified by earlier genetic methods for similar traits. Because the molecular methods are more specific, users of these methods will be more certain about the traits they introduce into the plants."²⁴

National Academy of Sciences (NAS) Statement on Safety

The National Academy of Sciences (NAS) published a landmark white paper in 1987 on the introduction of organisms derived through agricultural biotechnology. This white paper has had significant impact in the U.S. and other countries. Its most significant conclusions include: (1) There is no evidence of the existence of unique hazards, either in the use of rDNA biotechnology techniques or in the movement of genes between unrelated organisms, and (2) Any risks associated with the introduction of biotechnology-derived organisms are the same in kind as those associated with the introduction of unmodified organisms and organisms modified by other methods.

National Research Council (NRC) Statement on Safety

In a 1989 extension of this white paper, the National Research Council (NRC), the research arm of the NAS, concluded that “no conceptual distinction exists between genetic modification of plants and microorganisms by classical methods or by molecular techniques that modify DNA and transfer genes.” The NRC report supported this statement with extensive observations of past experience with plant breeding, introduction of biotechnology-derived plants and introduction of biotechnology-derived microorganisms.²⁵

National Institutes of Health (NIH) Statement on Safety

The National Institutes of Health (NIH) emphasized the same principles in their 1992 report by the U.S. National Biotechnology Policy Board. This board was established by U.S. Congress and composed of representatives from the public and private sectors. They found that “the risks associated with biotechnology are not unique, and tend to be associated with particular products and their applications, not with the production process or the technology per se. In fact, biotechnology processes tend to reduce risks because they are more precise and predictable. The health and environmental risks of not pursuing biotechnology-based solutions to the nation’s problems are likely to be greater than the risks of going forward.”²⁶



UK’s House of Lords Statement on Safety

The UK’s House of Lords Select Committee on Science and Technology released a similar position. “As a matter of principle, GMO-derived products [i.e., those from genetically manipulated organisms, or recombinant organisms] should be regulated according to the same criteria as any other product...UK regulation of the new biotechnology of genetic modification is excessively precautionary, obsolescent, and unscientific. The resulting bureaucracy, cost, and delay impose an unnecessary burden to academic researchers and industry alike.”²⁷

United Nations/World Health Organization Statements on Safety

Three joint UN FAO/World Health Organization (WHO) consultations addressing the safety of biotechnology-derived foods came to similar conclusions. In 1991, the first of these expert consultations concluded: “Biotechnology has a long history of use in food production and processing. It represents a continuum embracing both traditional breeding techniques and the latest techniques based on molecular biology. The newer biotechnological techniques, in particular, open up very great possibilities of rapidly improving the quantity and quality of food available. The use of these techniques does not result in food which is inherently less safe than that produced by conventional ones.”²⁸

In 1996, the second UN FAO/WHO consultation came to the same conclusions as the first: “Food safety considerations regarding organisms produced by techniques that change the heritable traits of an organism, such as rDNA technology, are basically of the same nature as those that might arise from other ways of altering the genome of an organism, such as conventional breeding...While there may be limitations to the application of the substantial equivalence approach to safety assessment, this approach provides equal or increased assurance of the safety of food products derived from genetically modified organisms as compared to foods or food components derived by conventional methods.”²⁹

In 2000, the third UN FAO/WHO consultancy concluded: “A comparative approach focusing on the determination of similarities and differences between the genetically modified food and its conventional counterpart aids in the identification of potential safety and nutritional issues and is considered the most appropriate strategy...The Consultation was of the view that there were presently no alternative strategies that would provide better assurance of safety for genetically modified foods than the appropriate use of the concept of substantial equivalence.”³⁰

Organisation for Economic Co-operation and Development (OECD) Statement on Safety

The Organisation for Economic Co-operation and Development (OECD) offered several conclusions and recommendations that are wholly consistent with the NAS, NRC and UN FAO/WHO findings:

“In principle, food has been presumed to be safe unless a significant hazard was identified. Modern biotechnology broadens the scope of the genetic changes that can be made in food organisms and broadens the scope of possible sources of foods. This does not inherently lead to foods that are less safe than those developed by conventional techniques. Therefore, evaluation of foods and food components obtained from organisms developed by the application of the newer techniques does not necessitate a fundamental change in established principles, nor does it require a different standard of safety. For foods and food components from organisms developed by the application of modern biotechnology, the most practical approach to the determination of safety is to consider whether they are substantially equivalent to analogous conventional food product(s), if such exist.”³¹

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Source: Organization for Economic Co-operation and Development

In 1998, OECD addressed the issue of potential allergenicity in biotechnology derived foods. The report stated: “While no specific methods can be used for proteins derived from sources with no history of allergy, a combination of genetic and physicochemical comparisons exist which can be used as a screen. The application of such a strategy can provide appropriate assurance that foods derived from genetically modified products can be introduced with confidence comparable to other new plant varieties.”³²

In 2000, OECD acknowledged public concerns about their safety assessment of agricultural biotechnology, stating: “Although [the] food safety assessment is based on sound science, there is a clear need for increased transparency and for safety assessors to communicate better with the public. Much progress has already been made in this regard...However, more could be done in this area.”³³



National Research Council (NRC) Statement on Safety

Also in 2000, the NRC's Committee on Genetically Modified Pest-Protected Plants found that “there is no strict dichotomy between, or new categories of, the health and environmental risks that might be posed by transgenic and conventional pest-protected plants” and that the “properties of a genetically modified organism should be the focus of risk assessments, not the process by which it was produced.” The committee concluded that “[w]ith careful planning and appropriate regulatory oversight, commercial cultivation of transgenic pest protected plants is not generally expected to pose higher risks and may pose less risk than other commonly used chemical and biological pest-management techniques.”³⁴

European Commission's Joint Research Centre Statement on Safety

In 2008, the European Commission's Joint Research Centre reconfirmed the results of a 2001 Commission study concluding that no demonstration of any health effect of biotech food products has ever been reported and the use of more precise technology and the greater regulatory scrutiny very likely makes them even safer than conventional plants and foods.³⁵ Specifically, the report noted, “*There is a comprehensive body of knowledge that already adequately addresses current food safety issues including those dealing with GM products; it is considered by the experts as sufficient to assess the safety of present GM products.*”³⁶

Biotechnology Provides Nutritional Benefits

Since the early efforts of biotechnology, scientists have planned to use the technology to make more nutritious foods to benefit consumers around the world. As the technology developed, the first generation of agricultural biotechnology products were focused more on input traits, which means these modifications made insect, virus and weed control easier or more efficient for farmers. These first products have been rapidly adopted by U.S. farmers, and now account for the majority of soybeans, cotton and corn grown in the U.S.³⁷

Agricultural biotechnology varieties focused on consumer benefits are often called output traits. These products spent much more time in development, but are moving towards commercial availability. Many of these would fit into the category of “functional foods” because they provide added nutrition compared to their conventional counterparts. Following are some examples of trait improvements in the pipeline.

Increased Oleic Acid Soybeans

Creating more stable frying oils can eliminate the need for hydrogenation, the process that often introduces trans fat. Therefore, the use of agricultural biotechnology to develop soybean oils for the food industry with increased levels of oleic acid for oxidative stability can translate into a consumer benefit of food products with zero grams of trans fat.

Products requiring high heat during processing will benefit from these oils because of a superior resistance to flavor breakdown. Most varieties of increased oleic will also have a reduced linolenic acid content for further stability. Applications for mid-oleic soybean oil include usage as a spray oil for crackers, coating oil for baked goods and as a blending component for formulating numerous types of margarines and shortenings. Mid-oleic is 50 to 70 percent oleic content with a maximum 3 percent linolenic acid, and is expected to be commercially available in late 2008.

High oleic acid soybean oil will further extend usage of soybean oil in bakery applications beyond the applications supported by mid-oleic. High-oleic will be more than 70 percent oleic content with a maximum 3 percent linolenic acid. These enhanced oils can make a tremendous difference in the baking arena. Bakers require trans fat solutions that work with solid fats in order to produce baked goods with pleasant taste and texture. High oleic acid soybean oils will be commercially available in 2009.

Scientists are using biotechnology to help develop enhanced soybean oils for the food industry, which can translate into a consumer benefit of food products with zero grams of trans fat.



High Isoflavone Soybeans

A wide body of research indicates multiple health benefits of consuming soy, including: alleviating menopausal symptoms^{38,39}, reducing cardiovascular disease risk^{40,41}, reducing risk of certain cancers^{42,43,44} and increasing the bone density of postmenopausal women^{45,46}. Soyfoods are the only natural dietary source of isoflavones, a phytoestrogen that may be responsible for many of these health benefits. Isoflavones (such as genistein) are believed to have estrogen-like effects in the body; they have a chemical structure similar to estrogen that binds to both estrogen receptors alpha (ERa) and beta (ERB).^{47,48}

In soybeans and unprocessed soyfoods, each gram of soy protein is associated with about 3.5 mg of isoflavones.⁴⁹ One serving of a traditional soyfood, such as 3 to 4 ounces of tofu or 1 cup of soymilk, provides about 25 mg of isoflavones. While daily adult isoflavone intake in Japan and certain locations in China ranges on average from about 25 to 50 mg,⁵⁰ average isoflavone intake in the U.S. and other Western countries is less than 3 mg per day.⁵¹

A soybean with increased isoflavones content could deliver more of the associated health benefits without consumer populations needing to remarkably increase their soy intake. High-isoflavone soybeans are currently being developed through genetic engineering and this new variety will have approximately four times the typical isoflavone content of conventional soybeans. High-isoflavone soybeans are expected to be commercialized around the year 2016.

Conjugated Linoleic Acid Soybeans

Conjugated linoleic acid (CLA) has several benefits for human health including reduced body fat,⁵² improved serum lipid profiles and increased aortic lipid deposition, all of which have cardiovascular benefits.⁵³

CLA is found naturally in dairy and beef products at levels of 0.2 to 2 percent of the total fat. A more concentrated source of dietary CLA that is also low in saturated fat would be highly desirable to obtain optimum CLA levels of about 3 g/d.⁵⁴ Over the last 50 years, changes in livestock development practices have largely removed naturally occurring CLA from our diets.

The CLA soybean is still under development and is expected between 2012 and 2015.

Low Phytate Soybeans

Iron deficiency anemia is one of the most widespread nutritional deficiencies in the world. The UN estimated in 2008 that over 1.62 billion people worldwide, or almost 25 percent, are iron-deficient.⁵⁵ The problem for women and children is more severe because of their greater need for iron. For this reason, the enrichment of staple foods, especially those consumed in poor countries, is a top priority in international agricultural and nutrition research.

Absorption inhibitors such as phytate, a phosphorus storage compound found in the seeds of many edible crops including soybeans, may contribute to iron deficiency anemia. Phytic acid forms salts (phytates) of potassium, magnesium, calcium, iron, zinc and other minerals that cannot be absorbed. Phytic acid containing foods bind minerals in the intestinal tract rendering them unavailable. When a diet is limited in proper mineral intake, the presence of phytic acid can contribute to mineral deficiencies, particularly in the case of iron and zinc. This is especially important for women and children eating legumes and cereals as staple foods.

In addition, zinc can also be deficient in human diets, especially in populations where meat is not consumed. Zinc deficiency is associated with impaired growth and reproduction, anorexia, immune disorders and a variety of other symptoms. Zinc is also an important constituent of more than 100 enzymes. Absorption of zinc from cereals and grains can be impaired or blocked by the presence of some substances such as phytate.⁵⁶

Reducing the phytate content of plants, particularly soybean, has direct implications for human nutrition. For example, low phytate soy protein used in infant nutrition may improve mineral absorption compared to traditional soy infant formula. A recent study found that zinc absorption was significantly greater from dephytinized formula compared with regular formula, at 22.6 percent compared with 16.7 percent absorption.⁵⁷

Lines of corn, barley, rice and soybeans with slightly different phytic acid characteristics have been used to develop varieties with reduced seed phytic acid.⁵⁸ In soybeans and corn, 80 percent reduction has been achieved. The challenge now is improving yields of these crops.⁵⁹ The low phytate soybeans will be commercially available in 2011.

New varieties of soybeans are currently being developed that will offer 50 percent more iron bioavailability from the diet, with the opportunity to make a real difference in the lives of people with anemia. These-new soybeans will be more easily digested and provide high energy content for both people and animals.



According to scientists in Britain, genetically modified crops are the only sustainable way of adding sufficient omega-3s into the food chain without damaging fragile fish stocks.⁶¹

Increased Omega-3 Soybeans

Soybean oil is one of the few non-fish sources of omega-3 polyunsaturated fatty acids, which have various physiological benefits including cardioprotective effects. While fish oil is the preferred source of omega-3s because of the bioavailability of eicosapentaenoic (EPA) and docosahexaenoic acid (DHA), consumption of the long-chain omega-3s found in fish is low in many countries worldwide. In the U.S. diet for example, the alpha-linolenic acid (ALA) in soybean oil is the principal source of omega-3s because fish consumption is relatively low. Meanwhile, less than 25 percent of British adults consume the recommended quantities of critical omega-3 fatty acids.

Researchers are developing soybeans even richer in omega-3 content, with greater bioavailability than ALA. The goal of these enriched soybeans is to create an affordable, land-based, renewable source of omega-3s that can be used as an alternative to fish to create great-tasting foods rich in this essential nutrient. The first of these innovations will be a soybean with increased stearidonic acid (SDA), which converts to EPA and DHA more efficiently than ALA. A high EPA/DHA soybean is further in the research pipeline.

A number of studies have shown that high intake of omega-3 fatty acids is associated with lower risk of death from cardiovascular disease, and consumption of vegetable oils rich in linolenic acid could confer important cardiovascular protection.⁶⁰ In addition, omega-3 DHA is known to keep brain cell membranes healthy and appears to aid communication within brain cells. DHA is a long-chain omega-3 fatty acid found throughout the body, especially in the brain and eyes.

The resulting soybean oil products are expected to have six times the bioavailable omega-3 content as traditional soybean oil, which has seven percent. The SDA oil, which is expected in 2011, will most likely be used as an additive to fortify traditional oils.

High Stearic Acid Soybeans

Saturated fatty acids provide important functional properties to edible fats and oils because they are more stable to heat and processing than unsaturated fatty acids. For this reason, the use of saturated fats in cooking and baking is important. However, saturated fats are known to negatively impact cardiovascular health.

However, biotechnology has been used with soybeans to produce oil enriched in stearic acid, a saturated fatty acid that scientists believe does not raise serum cholesterol levels unlike other saturated fats with shorter carbon chains and unlike trans fats.⁶² University-based researchers are currently completing a literature review that examines the full body of literature on stearic acid and clinical biomarkers for heart disease; preliminary results suggest neutrality on blood cholesterol and little or no effect on other markers such as fibrinogen levels. This research suggests not all saturated fats are created equal, and biotech products higher in stearic acid could provide viable, healthier options for the food industry.

Oil crushed from high-stearic acid soybeans is projected to have four to six times more stearic acid than the three percent that is present in conventional soybean oil. Expected to be commercially available in 2009, this oil will be stable enough to make soft spread margarine without the need for hydrogenation. If stearic acid levels reach 30 percent in the future, confectionery use without hydrogenation is potentially possible as well.

High Beta-Conglycinin Soybeans

Researchers are working to develop a new high beta-conglycinin soybean, which will provide soy protein with better taste, texture and ability to blend with foods. Beta-conglycinin is a naturally occurring, texture- and flavor-improving compound. The new soybean variety will also contain more soluble protein than any other soy protein on the market.⁶³ This soybean is being developed through conventional breeding, but in the U.S. it will be genetically modified for herbicide resistance. High beta-conglycinin soybeans will be commercially available in 2011.

Agricultural biotechnology can benefit consumers around the world through the introduction of *functional foods* with added nutrition compared to conventional counterparts.



Biotechnology and Environmental Sustainability

Farmers live off the land, and so they take their environmental stewardship very seriously. Agricultural biotechnology helps farmers provide a sustainable future for the world's agriculture systems. Extensive and repeated studies continue to verify that biotechnology derived crops pose no risks to the environment unique or different from conventionally developed crops. In fact, these studies show that biotechnology significantly reduces agriculture's impact to the environment.

Reduced Pesticide Use

Biotechnology provides targeted pest control methods that are dramatically reducing impacts on non-target species. In 2005, biotech varieties markedly reduced farmers' needs to use pesticide applications, eliminating 69.7 million pounds of pesticide use in the U.S. alone.⁶⁴ Globally, it is estimated that pesticide applications decreased six percent in the interval from 1996 to 2004, eliminating 379 million pounds of pesticide applications.⁶⁵

Soil Management and Conservation Tillage

Although "no-till" was feasible on a limited number of farmland soil types and in a limited number of U.S. latitudes prior to the arrival of biotech crops, the biggest environmental impact of biotech crops has been the adoption of no-till farming. No-till was made feasible on many more U.S. soil types and in many more latitudes by herbicide tolerant soybeans. In 2006, 89 percent (66.68 million acres) of U.S. soybean acreage was planted with herbicide-tolerant varieties. Worldwide, 53 percent of all biotech crops were herbicide-tolerant soybeans. These biotech varieties enabled farmers to almost completely eliminate plowing on their applicable fields, which results in significant benefits in terms of soil health and conservation, improved water retention/ decreased soil erosion and decreased herbicide runoff.⁶⁶



Agricultural biotechnology helps farmers provide a sustainable future for the world's agriculture systems.

Water Quality

Most of the phosphorus in conventional soybeans is in an indigestible form called phytic acid or phytate. Monogastric animals such as pigs and poultry do not have the digestive enzymes to degrade this phytate into a form of phosphorus that can be utilized. To remedy this problem, producers add inorganic phosphorus to the diet. The end result of the poor phosphorus utilization and the high amount of inorganic phosphorus that must be added to the diet is that excessive phosphorus is excreted in the manure. This contributes to environmental pollution when the phosphorus enters streams and waterways.

A gene for production of phytase has been successfully incorporated into soybean and wheat, and is biologically active when the plants are used as animal feed.⁶⁷ In a study of broiler chickens, consumption of biotech soybeans containing phytase led to a 50 percent reduction in phosphorus excretion compared with a diet supplemented with an intermediate level of nonphytate phosphorus.⁶⁸ Feeding the biotech soybeans resulted in an 11 percent greater reduction in phosphorus excretion than feeding with conventional soybeans to which the enzyme is added.

Biotechnology is also being used in the development of low phytate soybeans and corn by silencing the phytate gene in the seeds.⁶⁹ The resulting animal feed will allow livestock producers to save money they would have spent on dietary supplements and it will also reduce phosphorus pollution and improve water quality. The new soybean seed is expected to be commercially available in the next decade.



Reduced Greenhouse Gasses

No-till farming reduces the use of agricultural machinery in fields, which leads to a significant reduction in greenhouse emissions from farm equipment. In fact, crops derived from agricultural biotechnology resulted in a significant reduction in the emission of carbon dioxide (CO₂) into the environment. This reduction in CO₂ emissions with biotech crops comes from two sources:

- **Reduction in the use of diesel fuel in biotech crops, due to a reduction in pesticide spray applications and a reduction in plowing.**
- **An increase in the amount of carbon held in the soil due to a reduction in plowing associated with biotech crops.**

These two factors contributed to a combined (conservative) reduction equal to a 14.76 billion kg of CO₂ in 2006. This is the equivalent of removing 6.56 million cars from the roads for one year.⁷⁰

Gene Flow and Outcrossing Risk

Herbicide tolerant soybeans have limited gene flow risk to nonbiotech varieties. There are several reasons for this. Soy self-pollinates, which means it is less prone to gene flow than crops that cross-pollinate. In addition, there are no sexually compatible wild relatives in North America. It is estimated that outcrossing rates between adjacent plants are two percent or less.⁷¹

Pest Resistance

Issuance of formal import approvals for the LIBERTY LINK™ soybean (which is resistant to glufosinate-ammonium herbicides) by all applicable overseas markets means that, beginning in 2009, U.S. farmers will have the freedom to rotate between usage of different herbicides on soybean fields, thereby helping to prevent the arising of glyphosate- (ROUNDUP™ Agricultural Herbicide)-resistant weeds.^{72 73 74}

Biodiversity

No-till agriculture maintains soil health, the conservation of topsoil and moisture content. It also encourages the growth of habitats that support different varieties of wildlife. For example, studies have shown that songbirds have actually returned to agricultural fields in increasing numbers as biotech crop acreage has increased.⁷⁵

In addition, the vastly-increased usage of no-till and other conservation-tillage production practices facilitated by biotech herbicide-resistant soybeans has made the U.S. soybean crop significantly less vulnerable to drought.⁷⁶



This report quantified the impact biotechnology is having on the global agriculture system from a community, health, and environmental perspective.

It demonstrated that biotechnology has the power to increase human health, environmental sustainability and the well-being of consumers and farm communities globally.

- Higher yielding crops developed through agricultural biotechnology can contribute toward meeting the United Nation's estimated need for a 50 percent increase in world food production by 2030.
- More nutritious crops developed through agricultural biotechnology can help consumers meet specific nutrient needs such as increasing omega-3 fatty acid consumption or reducing saturated fat consumption.
- These improved crops have been declared safe repeatedly by the world's top scientific and regulatory bodies, so consumers can feel safe eating foods with biotech-derived ingredients.
- Farmers can contribute to sustainable farm communities by earning higher incomes for biotech-derived crops.
- Better soil health, improved water retention/ decreased soil erosion and decreased herbicide runoff are resulting from the use of biotechnology.
- Agricultural biotechnology is decreasing CO2 emissions from farming.



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The United Soybean Board (USB) is a farmer-led organization comprised of 68 farmer-directors who oversee the investments of the soybean checkoff for all U.S. soybean farmers. Soybean farmers are united by a commitment to produce wholesome, nutritious foods that can help sustain and nourish an ever-increasing population. And, soybean growers take pride in their role in producing one of the healthiest food crops in the world. USB has invested millions of dollars into health and nutrition research related to soy. For more information, please visit www.soyconnection.com.

The U.S. Soybean Export Council (USSEC) is a dynamic partnership of key stakeholders representing soybean producers, commodity shippers, identity preserved value-added merchandisers, allied agribusinesses and agricultural organizations. Through its global network of international offices, operating overseas as the American Soybean Association-International Marketing, activities are carried out that will create and sustain demand for U.S. soybeans and soybean products.

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