GM CROPS: THE FACTS AND ONLY THE FACTS

An overview of facts, data and 25 years of experience that show that genetically modified crops are safe and bring operational, agronomic, social and environmental benefits

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Overview

After more than 25 years' experience in the commercial production of genetically modified (GM) or agricultural biotechnology crops, by 2019 a total of 71 countries had adopted GM crops of which 29 countries successfully grew GM crops. The 17 million farmers who grow these crops in these 29 countries do so because they find that the technology works as a successful farm tool delivering tremendous environmental and safety benefits.

Millions of consumers across the world have eaten foods made or derived from GM crops with no identified health problems. Livestock, poultry, and companion animals have eaten billions of GM feed from biotech crops and their health and welfare have steadily improved. Overall, the environmental benefits through reduced fuel use, lower greenhouse gas emissions, less soil erosion, reduced food waste and lower food costs have benefited society.

Despite a wealth of verified scientific and practical evidence, some critics remain unconvinced of the proven benefits of the technology and continue to oppose the use of GM in food and feed production. That may be their right. However, the challenge facing everyone, is global food security. Time is pressing. Already more than 820 million go hungry every day. In less than 10 years a further 1 billion people will have been added to the world's population. To provide and supply enough food for the world's growing population by 2030 is described by the United Nations as "*an immense challenge*".

From time immemorial, farmers have faced volatile weather, weeds, soil erosion, damaging pests to name a few as they strive to produce sufficient food. And from time immemorial, they have sought ways to farm better through safe tools and technologies. As the world's farmers gear up to meet the UN's "immense challenge", today's farmers across the globe will need all the help, innovation, and technologies if they are to close the food security gap.

Before he died, the last words uttered by Norman Borlaug, Nobel Peace Prize Laureate, and father of the Green Revolution, were "*Take it to the farmer.*" He understood that for all of us on this planet we are reliant on the world's farmers to provide safe, nutritious food using the best and most practical methods. Agricultural biotechnology is simply one of those methods.

Authors Note

GM Crops: The Facts and Only the Facts was compiled by David Green and Benno van der Laan of GreenOrange, LLC, who for 25 years have followed the development of agricultural biotechnology around the world and written, presented and advised clients on the technology. GreenOrange is an independent consulting firm specializing in food and agriculture communications.

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FACT 1: Genetically modified crops and foods are safe

Genetic modification (GM) is an extremely precise form of plant breeding. 'Traditional' breeding involves the transfer of many genes from one plant to another, which means a lot of trial and error as gene transfer cannot be exactly predicted. Alternatively, genetic modification involves precisely selecting specific known genes for transfer. GM technology does not necessarily involve the introduction of any new genes from another species. Some techniques simply involve maximizing beneficial genes or reducing negative genetic traits for better crop outcome.

Since 1996, the technology has contributed significantly to the reduction of the amount of pesticides used by farmers and resulted in lower levels of toxins and food allergens in the food supply. It allows for the development of diagnostic techniques to detect allergens present in foods, and therapeutic interventions to prevent sensitive individuals from reacting if they are inadvertently exposed to an allergen. Given the above, crops and foods improved through genetic modification are at least as safe as, and in some cases safer than, those produced through other methods. There is not one example, worldwide, of illness or harm from consumption of GM food or feed caused by the genetic change involved.

The safety of GM foods has been confirmed by every competent body that has considered the issue. Indeed, the only time a safety differential has been confirmed, it was found that biotech crops and foods safer.[1] To date, more than 3,000 scientific studies have assessed the safety of GM crops for human health and environmental impact. These studies, together with numerous reviews performed on a case-by-case basis by regulatory agencies around the world, have enabled a solid and clear scientific consensus: GM crops have no more risk than those that have been developed by conventional breeding techniques.

A report by the scientific academies of Brazil, China, India, the UK, the U.S. and the Third World Academy of Sciences emphasized the safety of GM crops: "*GM technology …. should be used to increase the production of main food staples, improve the efficiency of production, reduce the environmental impact of agriculture, and provide access to food for small-scale farmers.*"[2]

A non-profit initiative, *Sí Quiero transgénicos*, analyzed 284 technical and scientific institutions and concluded that all the studies recognized the safety of GM crops and their potential benefits. Paradoxically, most of these institutions are in Europe, where anti-GM sentiment and obstacles to GM crops have been strongest and often misinformed.

FACT 2: Consumers around the world have eaten trillions of meals produced or derived from GM food products with no evidence of any adverse effects

Consumers worldwide have been eating GM derived crops in many forms since 1994 with no sign of any health or safety problems.[3] This observation is consistent with the numerous peer reviewed studies on the safety of biotechnology crops for humans, animals, and the environment.[4]

The European Commission funded more than 130 studies on the safety of GM crops covering more than 300 research groups over a period of 25 years.[5] One such study, by the European Commission's Joint Research Centre in 2008, concluded:

"*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*." [6]

The German Academy of Sciences reported that:

"*…in consuming food derived from GM plants approved in the EU and in the USA, the risk is in no way higher than in the consumption of food from conventionally grown plants. On the contrary, in some cases food from GM plants appears to be superior in respect to health.*" [7]

And the United Kingdom's Council for Science & Technology stated:

…. "*Notably, even in the highly litigious USA, there have been no successful lawsuits, no product recalls, no substantiated ill effects, and no other evidence of risk from a GM crop product intended for human consumption since the technology was first deployed commercially in 1994.*" [8]

GM has helped to provide better nutrition in several foods such as GM soybeans that have lower saturated fat, increased isoflavone content and higher levels of omega-3 fatty acids. Various GM crops with health benefits have been developed in which genes have been added, such as rice enriched with pro-vitamin A (Golden Rice) and folate-enriched rice. To date, six major staple crops have been successfully biofortified with one or more vitamins or minerals.

Without GM technology, it is unlikely that papaya would have survived as a crop. By 1995, the papaya ringspot virus almost wiped out the fruit in Hawaii which grows 95 percent of the world's papaya. In 1998, the first GM ringspot-resistant papaya was commercialized and today the fruit is once again enjoyed by consumers in numerous countries across the world.[9]

FACT 3: GM foods are far less likely to present allergy issues as they are the only foods screened in advance for allergenic potential

The major allergenic foods are well-known: peanuts, tree nuts, fish, shellfish, cow's milk, eggs, wheat, and soy. All foods containing these ingredients must indicate that fact on the label, including GM-derived foods. If a food from any of these categories is improved through biotechnology it is likely to remain allergenic, and therefore a concern for, and avoided by, susceptible individuals. Any foods containing proteins sourced from these classes of allergenic foods would be of similar concern.

But unlike other foods, those improved through biotechnology are screened in advance to reduce the potential that they could cause an allergic reaction. In cases where a novel protein is added to a food item, the genes that encode that protein's structure are screened against a database containing the DNA sequences for all known allergenic proteins, so that any with similar structures can be examined closely to ensure they do not cause allergies. Every biotech-improved food placed on the market to date has been screened in this way, and none have been shown to present any novel allergenic hazard.

Far from presenting a potential allergy hazard, biotech-improved foods have the potential for reducing potential hazards for allergic individuals by reducing the allergenic proteins in foods. Researchers are working, for example, to eliminate from peanuts (and other allergenic foods) the genes that encode for the production of the proteins to which sensitive individuals are allergic.[10] Clinicians are also using biotechnology to develop novel immunotherapies to block the allergenic response among sensitive individuals when they might be exposed to an allergenic protein.[11]

The reality is that GM derived foods are far less likely to present allergy hazards than any other foods, and biotechnology is being used by researchers working to protect sensitive individuals from accidental exposure to natural allergens.

FACT 4: Biotech crops help to increase food safety

Biotech crops are making food safer, by reducing pesticide residues and, in the case of Bt maize (maize), by reducing mycotoxin contamination.

The Union of the German Academies of Science and Humanities' Commission on Green Biotechnology reported, "*food from biotech maize is healthier than from conventionally grown maize*."[12] This is because contamination of maize by the carcinogenic fungal toxin, fumonisin, is reduced in biotech insect-resistant Bt maize.

The importance of reducing fumonisin levels cannot be over-emphasized. Fumonisin is a mycotoxin, a neurological poison released by fungi of the genus *Fusarium*, a common grain mold which grows on food plants, either due to poor storage or to insect damage that provides entry for the fungal spores. Developing countries are often most prone to fungi infestation in maize crops often leading to deaths.

Countries with modern agricultural systems, regular testing, good dry storage, and judicious use of chemicals can minimize mycotoxins. However, the issue is global in all cereal crops not least the European Union, particularly Italy.[13] In fact, the incidence of mycotoxin infestation is such that the European Food Safety Authority (EFSA) released a video on *Mycotoxins and Climate Change*, highlighting how changes in temperature, humidity, rainfall and carbon dioxide production impact on fungal behavior and consequently on mycotoxin production.[14]

An article in *New Food Magazine* reported that a study by the University of Milan showed that a sample of biotech Bt maize contained 60 or fewer parts per billion of mycotoxins. In contrast, the conventional maize contained more than 6,000 parts per billion, a level that European law deems too high for human consumption. [15] Several studies by researchers confirm the concern of increasing levels of aflatoxin and mycotoxin infestation and the links to changing weather patterns. [16] [17] [18]

Bt maize (corn) is a powerful and effective way to reduce fumonisin to a safe level without chemicals. Its built-in pesticide against the maize borer greatly reduces plant damage, and thereby removes most of the risk of fungal spores getting inside before processing.[19]

In a 2020 article, *The Human Health Benefits from GM Crops*, the author states that insect-resistant crops have a "noticeable potential to improve human health through the reduction in cancer rates" by reducing the levels of mycotoxins in maize consumed as part of the household diet in many developing countries.[20]

FACT 5: Agricultural biotechnology offers substantial benefits to farmers, the environment, and increasingly to consumers

Widespread and significant benefits to farmers and the environment are well documented.[21] And the next generation of GM soybeans has already begun to deliver direct consumer benefits through improved vegetable oil profiles, and benefits will increase in coming years.[22]

Food waste is reduced and quality improved by potatoes that resist bruising and produce less carcinogenic acrylamide when fried.[23] These are now available to consumers, as are apples that do not brown when cut.[24] A biotech improved salmon can reach market size in half the usual time on less feed. This salmon can be grown in land-based recirculating tanks which reduces the threats from sea-pen escapees to wild populations. It is already available in Canada and is expected to reach U.S. consumers in 2021.[25]

Additional beneficial traits include cooking oils with lower saturated fat, increased isoflavone content and increased omega-3 fatty acids. Scientists in the United Kingdom report that GM crops are an excellent, sustainable way to add sufficient omega-3 into the food chain without further damaging stressed fish stocks.[26] Other new varieties will offer the availability of 50 percent more iron in the diet which will help consumers with anemia. The United Nations estimates 1.62 billion people worldwide are iron deficient.[27] High oleic acid soybeans help to eliminate the need for hydrogenation of soybean oil – a process which introduces trans fats.

Regardless of these direct benefits, it is incorrect to claim an absence of 'consumer benefits' from GM crops as some anti-GM campaigners claim. The reality is that all consumers live in the environment; and the environmental benefits of cleaner, higher quality and safer harvests produced using less water, chemicals, and diesel fuel as well as substantial reductions in topsoil loss and greenhouse gas emissions benefit consumers around the globe. This is best summed up by the European Commission report *A Decade of EU-funded GMO Research (2001-2010)* which concluded:

"Biotechnologies could provide us with useful tools in sectors such as agriculture, fisheries, food production and industry. Crop production will have to cope with rapidly increasing demand while ensuring environmental sustainability. Preservation of natural resources and the need to support the livelihoods of farmers and rural populations around the world are major concerns we must consider all the alternatives for addressing these challenges using independent and scientifically sound methods These alternatives include genetically modified organisms (GMO) and their potential use." [28]

FACT 6: Consumers today have unprecedented access to information about GM foods, and labels provide multiple choice options

Several GM crops have already begun to deliver numerous direct consumer health and nutritional benefits. These will increase in the coming years as research across the world, including South Asia, continues to expand. For example, In Bangladesh, public sector research institutes and public universities are in the process or research and development of three more GM brinjal varieties; a tomato that is resistant to leaf curl; blight resistant potato; salt tolerant wheat and ringspot-resistant papaya.

Other crops also provide better nutrition such as GM soybeans that have lower saturated fat, increased isoflavone content and higher levels of omega-3 fatty acids. Various GM crops with health benefits have been developed in which genes have been added, such as rice enriched with pro-vitamin A (Golden Rice) and folate-enriched rice. To date, six major staple crops have been successfully biofortified with one or more vitamins or minerals.

A significant health benefit for consumers and livestock producers is the reduction in insect-related toxins in GM maize. Numerous studies show that insect damage to the ear in maize was reduced by up to 60 percent in the harvested crop. A 2018 study in *Scientific Reports* shows that results from more than 6,000 peer-reviewed studies covering 21 years of data found that GM maize dramatically decreased three major toxins which can cause cancer in humans with reductions of 28.8 percent in mycotoxins, 30.6 percent in fumonisins and 36.5 percent in thricotecens all of which can lead to economic losses and harm human and animal health.[29]

Farmers in India and Bangladesh who grow insect resistant GM cotton and Bangladeshi farmers growing Bt brinjal (eggplant) have greatly reduced the use of chemicals to control insect damage. As most farmers in both countries use handheld sprayers, being able to reduce the level of spraying – as many as 15 applications – has clear benefits in reducing any skin absorption of chemicals and for brinjal it means providing a crop with no evidence of insect damage.[30]

Consumers who wish to avoid biotech foods already have a label – 'Organic' they can turn to if they wish to avoid GM foods. Advocates claim mandatory labels are needed so that some consumers can make a choice to avoid foods derived through biotechnology enabling them to make a choice.

The implication is that safety concerns justify special labels. But with no safety problem associated with biotech foods a "GMO label" provides the consumer with no information to make an informed choice about any risk to their health, and in many cases serve only to mislead consumers.

FACT 7: Since GM crops were introduced, pesticide use has trended down while environmental impacts have declined dramatically

The reduction in pesticide use by farmers was one of the early and clear benefits to farmers who grow both insect resistant and herbicide tolerant crops. A June 2014 meta-analysis by German researchers Klűmper and Qaim concluded that:

"Our findings reveal that there is robust evidence of GM crop benefits … [which] has reduced chemical pesticide use by 37 percent, increased crop yields by 22 percent, and increased farmer profits by 68 percent. Yield gains and pesticide reductions are larger for insect-resistant crops than for herbicide-tolerant crops. Yield and profit gains are higher in developing countries than in developed countries."[31]

This has been reinforced by other studies in peer-reviewed literature, such as the multiple studies from Brookes & Barfoot (April 2018) which stated that:

"The adoption of GM HT crop technology [in 2016] continues to deliver a net environmental gain relative to the conventional alternative and, together with GM insect resistant technology, continues to provide substantial net environmental benefits".[32]

Farmers in Spain and Portugal who are among the few in Europe who grow Bt maize produced an extra 1.89 million metric tons, using fewer resources such as water, and with reduced cost of insecticides achieved higher incomes equal to an average of €173 a hectare and an average return on investment equal to more than €4.95 for each extra €1 spent on Bt maize seed relative to conventional seed.[33]

This study by PG Economics supported the 2008 findings by the European Commission's Joint Research Centre found that farmers who used Bt maize used fewer chemical inputs compared to conventional maize growers.[34]

FACT 8: Biotech crops are a boon to biodiversity

Biodiversity researchers are unanimous in identifying the loss and degradation of wild habitat as the most important threats to biodiversity.[35] The single largest driver of habitat loss is the conversion of native lands to agriculture. It follows, therefore, that more efficient agricultural production, as delivered by crops improved through biotechnology, which produce higher yields from less land than less efficient production methods, thereby will help to reduce agricultural threats to biodiversity.

Contrary to popular conception, it seems that "organic" farming, with yields consistently lower than from conventional farming, could be viewed as less environmentally-friendly than conventional agriculture using GM seeds.[36]

Some GM opponents have argued that gene flow from GM crop varieties, especially of herbicide tolerance traits, threatens wild species. But out-crossing and herbicide resistance are well-understood crop management issues that have been observed since long before GM crops were developed. There is no evidence that GM crops are, or will be, any less manageable than their conventional counterparts.

A July 2020 study by *PG Economics*, showed that from 1996 to 2018, crop biotechnology reduced the application of crop protection products by 776 million kilograms, a global reduction of 8.6 percent. As a result, farmers who grow GM crops have reduced the environmental impact associated with their crop protection practices by 19 percent.[37] For farmers in developing countries the use of GM crops provided a 53 percent environmental benefit because of reduced pesticide use. For GM cotton growers the reduction in insecticide use was 61 percent.

A 10-year study by a respected British ecologist found that biotechnology-derived herbicide-tolerant crops did not persist in the wild and were no more likely to invade other habitats than other, unimproved crop plants. The plants did not become self-seeding, self-sustaining plants, and they did not spread into surrounding areas.[38]

As a group of scientists at Britain's respected John Innes Centre concluded in a paper on the environmental impact of GM crops (Dale, 2002), "*we can find no compelling scientific arguments to demonstrate that biotech crops are innately different from non-biotech crops.*"[39]

FACT 9: The herbicides used on biotech crops are more environmentally friendly and safer for humans than those they replaced

Modern agriculture accomplishes control of weeds either through mechanical cultivation or through the application of herbicides. Weed pressure will vary by location, but maize and soybean farmers who use only mechanical cultivation (e.g., "organic" farmers) need to cultivate their fields as often as fourteen times per growing season.[40]

By contrast, the "no tillage" and "minimum tillage" crop production methods facilitated by GM seeds means much less field tillage and seed bed operations, which helps greatly to decrease soil erosion (wind and water) by 90 percent or more.[41] This is compared to as many as 10 field operations for non-GM production.

GM herbicide-tolerant crops deliver environmental benefits through at least three distinct paths: 1) they lead to reduced herbicide applications, often replacing multiple spraying passes to one or two; 2) the lead to reduced soil erosion, promoting no-till weed control, which minimizes soil erosion and the release of climate-changing carbon into the atmosphere; 3) the newer herbicides used in conjunction with GM improved crops are generally less toxic and less persistent than those they replace, reducing the potential for negative impacts.[42]

GM crops do not absolve farmers from the need for good stewardship. Any pest control measure, derived through biotechnology or other means, must be applied with care, and understanding, and follow standard good production practices and product guidelines. Otherwise, pests or weeds could evolve resistance and 'escape' the control measures. The emergence of glyphosate tolerant Palmer amaranth has become a severe problem in some parts of the U.S.[43] One solution - combinations, or "stacks" of dicamba tolerance with glyphosate tolerance, allowing both herbicides to be sprayed on the same crop.

The U.S. based Field to Market, a multi-stakeholder alliance for sustainable agriculture, emphasizes the need for continued research and development of management techniques based on a better understanding of both weed biology and ecology, and point to trends in precision agriculture, crop breeding and new biopesticide approaches as areas of promising research to develop alternative weed control systems.[44]

FACT 10: Weed and pest resistance is not the result of GM technology

Resistance to insecticides and herbicides chemicals is neither new nor a result of GM.[45] In fact, GM has helped delay resistance, especially when used with other pest control methods. For example, farmers using Bt maize can plant 'refuge' or non-GM areas to help reduce insect-resistance.

Weed resistance to herbicide tolerant (HT) crops can be countered or delayed through crop rotation and good crop management. When farmers can use several different herbicides rather than rely on a single product this also will delay resistance to any one herbicide. Stacked traits combining several different GM events will further help by providing a wider range of control and lower overall use of chemicals.[46]

What farmers generically refer to as refuge-in-a-bag is a combination of non-Bt maize (which serves as a refuge) and Bt insect-protected maize premixed in one bag of seed. This provides refuge areas for insects to develop without exposure to Bt toxins thus helping to slow the development of resistance.

To combat pest resistance, a 2015 study on refuge areas (designated areas in a field where non-Bt maize is grown) to combat resistance to Bt maize shows that:

"The purpose of planting non-Bt refuges is to sustain enough survival of susceptible insect populations such that these susceptible individuals develop without selection for resistance. Ideally, rare resistant insects originating from Bt plants will mate with these susceptible insects from the non-Bt refuge plants, and their resulting offspring will be killed by the high dose Bt proteins in the Bt plants."[47]

FACT 11: Commodity GM is 'one crop'

Commodity GM crops for export can be made up from many different varieties and are treated as 'one crop'. Following harvest, GM crop-specific varieties from many farms are gathered and mixed as a single export shipment, e.g. GM soybeans, to, for example, fill a 60,000 metric ton cargo for ocean-going vessels. This makes for an efficient bulk supply system. Care is taken to ensure other GM crops, e.g. maize, and traits not approved in the overseas market are not mixed in crop-specific shipments.

From the farm to an importing country, a commodity crop, usually soybeans or maize, will be stored, shipped, and used in bulk.

When a farmer stores his crop on the farm, it is more efficient to totally fill one grain bin, than to have two grain bins half-full of separate crop varieties. Further, for the bin's drying and aeration systems to work properly, bins must be nearly full to be effective.

When moving harvested crops from farm to local elevator or silo, farmers fill each truckload as full as possible to save time and maximize efficient transportation.

At the elevator, trucks unload their crop into large bins where they are mixed with similar crops from many farms. From there, crops are transported to export terminals by river barges, railcars or by road. At the port, crops are again mixed as one crop into large, ocean-going vessels for an overseas market.

FACT 12: Biotech crops help reduce greenhouse gas emissions

Crops improved through biotechnology have helped expand the use of no-till farming. A peer-reviewed analysis of the global impact on the environment of GM crops showed GM crops benefit the environment through reduced tillage and reduced diesel fuel use.[48]

For farmers everywhere, weeds are a constant problem. Farmers traditionally controlled weeds with tillage, hand weeding, herbicide sprays, or typically a combination of all techniques. Unfortunately, the effects of tillage include soil compaction, loss of organic matter, disruption of important soil microbes and earthworms and soil erosion through wind and water erosion, a serious long-term consequence for the environment.

Increasing numbers of farmers prefer no-till operations using herbicide-tolerant GM seeds knowing that they will have better weed control without tilling the soil. Basically, a farmer would traditionally use tillage primarily to bury weeds and aerate the soil. Preparing the seed bed following tillage also requires several field operations which mean more fuel use and specialist equipment. With no-till, farmers use a direct-drill seed planter where a narrow strip is cut into the soil, the seed is dropped in and the cut covered over.

No-till soils are healthier and are better able to sequester carbon and retain water, reduce topsoil erosion and runoff issues. No-till also prevents the release of a carbon compound, glomalin, into the environment. Data show that in 2016, the combined GM crop-related carbon dioxide emission savings from reduced fuel use and additional soil carbon sequestration were equal to the removal from the roads of 16.7 million cars, equivalent to 41 percent of all registered cars in the UK.[49] And a 2010 Purdue University study found that no-till cut nitrous oxide emissions by between 40 and 57 percent.[50]

An important benefit from no-till is the reduction in the physical strain on farmers and operator's well-being by not having so many field operations with tillage plus spraying their crops several times under previous production practices.

An uncelebrated benefit of no-till is an increase in earthworms undisturbed by tillage, which digest old crop residue and also create tunnels important for moisture penetration.[51] A study of conservation tillage by the American Soybean Association (ASA) found that 75 percent of growers who planted GM varieties reported that there was more crop residue on the soil surface using GM varieties.[52] Year after year, and layer after layer, this old crop residue breaks down to form new humic matter which is incorporated into the soil. As one Iowa soybean farmer puts it this way: "*for the first time in agriculture we are building topsoil*."[53]

FACT 13: Biotechnology has been a good deal for farmers.

Biotech crops have saved farmers money and reduced their workload. As well as being stewards of the land and living in the environment that others worry about, farmers are businessmen. If a tool or a technology did not work, they would not use it. If biotechnology did not deliver, if it did not offer farmers benefits in terms of operational efficiency, land husbandry and profitability, they simply would not use it year after year.

The most dramatic recent surges in GM crop adoption have been in developing countries such as Bangladesh, where farmers have rapidly embraced GM improved insect resistant brinjal (eggplant) which has delivered higher yields and profits while lowering pesticide use and input costs.[54] In neighboring India, Bt brinjal was approved in 2010, although implementation has been blocked by special interest driven politics. But impatient farmers appear to have begun to smuggle seeds across the border, planting them, and an increasing civil disobedience movement is defying government efforts to eradicate the practice.[55]

In Vietnam, an October 2020 report shows that farmers using an insect resistant and herbicide tolerant GM maize, enjoyed higher incomes equal to an average of between $196 per hectare (relative to equivalent conventional varieties) and US $330 per ha (average of all conventional varieties). These benefits resulted from the extra production and reduced cost of pest and weed control.[56]

In Europe, most farmers do not have the choice to grow GM crops. Many countries, under pressure from professional activist groups, have banned their cultivation. Currently, only one insect resistant GM maize event – approved in 1996 – is available. Spanish farmers have been enthusiastic users of this maize and production accounts for 85 percent of the 116,000 hectares (286,636 acres) of the production grown in only six EU countries.[57]

The Secretary-General of the EU farmers' and farm cooperatives association, Copa-Cogeca, called for EU farmers to have access to GM crops:

"….. *Farmers in Europe should have the right to be able to choose and to use this technology. But it is also important for farmers to have consumer acceptance and consumers in Europe have so far been reluctant to buy genetically modified produce…….The EU regulatory framework for approving genetically modified organisms needs to be correctly implemented. The use of modern biotechnology can help us to achieve this [increase production to meet growing demand], but it must be based on sound scientific advice, an efficient EU regulatory procedure and it must have consumer acceptance*".[58]

FACT 14: Farmers have multiple sources of seeds and are free to buy and save seeds with or without biotech-improved traits

The success of herbicide tolerant soybean production has resulted in much greater availability of many soybean varieties across all climatic zones in the North and South America. However, non-GM soybean varieties remain available for organic growers and those who wish to grow non-GM soybeans.

The cost of seed is often a relatively small part of a modern farmer's total cost of production, and the benefits of getting the latest varieties, selected to suit weather and soil conditions or expected pest pressures, and guaranteed by the breeder, invariably outweigh the savings and hassle of retaining enough seed from the previous harvest. All these considerations existed long before GM seeds became available.

Farm-saved seed is common in many countries, particularly developing countries such as Africa where farmer seed networks are seen as a key contribution to local agriculture because they provide the means of moving seed from farmer-to-farmer, local markets, national seed agencies, research facilities to farmers throughout the region. [59]

Farmers can choose which seeds they choose to grow and will select those seeds according to what makes the most sense for their farm. For open-pollinated field crops to which hybridization imparts a significant yield advantage (as a result of "hybrid vigor"), saving seeds can often be a disadvantage for most commercial farmers who enjoy higher profits from increased yields due to buying new seed each year.

Every commercial farmer knows that the most important factor is not the cost of the seed but the net value of the resulting crop. As such, they will prefer to purchase new seed each year. Continuous seed recycling can lead to poor yield because seeds take longer to mature and can be more prone to disease.

A closely related myth is the claim that the GM seeds cannot be saved because they are sterile, and their sterility will disable the ability of farmers to save other seeds that hybridize with GM seeds containing this "terminator" technology.[60] The deficiencies of this conspiracy theory are several: sterile seeds cannot convey any traits to subsequent generations because they are, by definition, incapable of reproduction.

FACT 15: GM crops are scale-neutral – benefitting both large and small farmers

GM crops deliver value regardless of the scale of the farming operation using them, working just as well for smallholders in the developing world as for large scale farmers in industrial nations.[61]

Of the more than 17 million farmers growing GM crops around the world in 2019, some 16 million were smallholders in developing countries, and they grew most GM improved crops planted that year.[62]

GM crops are widely grown outside the U.S. More than half of the world's GM crop acreage lies in developing countries where the adoption of agricultural biotechnology continues to advance twice as fast as in industrial countries.

The ISAAA (International Service for the Acquisition of Agribiotech Applications) reported in its bi-annual *Global status of Commercialization of Biotech/GM Crops* report (Brief 55 November 2020) that in 2019, GM crops were grown legally in 29 countries. Ninety percent of the more than 17 million farmers growing GM crops are smallholders in the developing world.[63]

FACT 16: The European Union imports massive amounts of GM crops

The EU both imports and processes large amounts of GM crops every year, without which its livestock and poultry sectors would not be viable. The EU has legislation in place to allow for importation and processing, but to date it has approved (1996) only one GM crop - Bt maize - for cultivation.

Several countries and commentators believe that the EU does not import or use any GM products because it has experienced more anti-GM concerns among consumers and politicians than any other region. It is correct that under a 2015 EU Directive many member states were able to opt out of cultivation in their countries. Both these facts led to a myth that the EU has banned all GM crops and food.

However, the reality is that: the EU has approved more than 100 GM events and imports more than 30 million metric tons of GM soybeans from the Americas every year. This imported GM soy is used in animal feed in every EU country, including those that oppose its cultivation.[64] European farmers argue that they too should have the choice to grow GM crops as well as their overseas counterparts.

The continuing political opposition by some EU Member States has slowed the EU's biotech approval process. This is of considerable concern to animal feed companies and farmers and poultry producers because slow approvals mean that GM crops approved and commercialized in other countries and not approved in the EU will be barred entry. For example, a GM trait that has been thoroughly assessed in the U.S. can expect to receive market authorization in 15 to 18 months. In Brazil, approval timelines are even less - 12 to 16 months. The EU average authorization timeline is six years on average.

FACT 17: Biotechnology has consistently delivered improved yields

Biotech crops increase yields by reducing losses to insect damage and weeds. They also reduce costs per land unit which in turn increases economic returns to the farmer.

The claim that biotech crops have not increased yields has been most creatively promoted in a paper self-published by a professional protest group.[65] The paper has been rebutted both in critical reviews [66] and concrete experience. Herbicide-tolerant crops allow farmers to better control weeds which would otherwise compete with the crop plants and prevent them growing properly.

Insect-resistant plants protect the crop from attack, especially from insects such as maize borer and bollworm which are notoriously difficult to control with sprays. In both cases, biotech crops provide a means to mitigate yield threats with less cost, less effort (e.g. fewer sprayings) and less chemical use.

A study published in *Scientific Reports* in 2020 showed that between 2001–2016, "*a significant inverse correlation existed between Bt corn planting and aflatoxin-related insurance claims in the United States, when controlling for temperature and drought*".[67] The estimated benefits of aflatoxin reduction from Bt maize was between $120 million to $167 million per year over 16 states on average. The report suggested that Bt maize is important in reducing aflatoxin risk, with corresponding economic benefits. If the same principles hold true in other world regions, then Bt maize hybrids adapted to diverse agronomic regions may have a role in reducing aflatoxin in areas prone to high aflatoxin contamination, and where maize is a dietary staple.

Herbicides have proved essential in maintaining yields without driving up costs prohibitively. A National Centre for Food & Agricultural Policy (NCFAP) study (Gianessi, 2003) calculated that without herbicides, crop producers could employ six million more workers to pull up weeds and still lose 20 percent of their crop to competition from weeds.[68]

A meta-study analysis by the Institute of Life Sciences in Italy, of 6,006 peer-reviewed studies from 1996 to 2016 showed that GM maize produced a greater yield of 5.6 to 24.5 percent compared to non-GM maize. Data came from GMO maize that had been planted in the United States, Europe, South America, Asia, Africa, and Australia. They were based on 11,699 observations of production, grain quality, and more.

The researchers also noted that some studies showed the use of GM maize reduced the active ingredient of herbicides and insecticides by 10.1 percent and 45.2 percent, respectively.[69]

FACT 18: GM crops offer superior sustainability benefits

Biotech crops are not a panacea to producing more food to meet growing populations. However, they are one of several important tools in 'a farmer's toolbox.' The food demands of the world's growing population will need to be met reliably and without unacceptable encroachment on bio-diverse habitats. As such, there is the pressing need to look to innovation and technology such as genetic modification, plant breeding innovations and precision agriculture to deliver safe and sustainable food.

The advantages over 25 years of GM crop production in lowering fuel use and thus greenhouse gas emissions, reducing soil erosion and compaction, using fewer chemicals, and producing safer crops are among some of the sustainable production benefits which are often missed by commentators.

Organic farming has its place and its strengths are concentrated in the low-yield production of food for those consumers willing to pay a premium for a more labor-intensive product they perceive as "natural" even though studies find no safety or health benefits.[70]

For price-sensitive commodity crops such as wheat and cotton, and soybeans and maize for animal feed, all of which comprise a major part of U.S. farming, organic methods can be costly, with lower yields, and more likely to be prone to insect and weather problems to work on a mass scale.

A report by the Council for Agricultural Science and Technology (CAST) carried an extensive literature review which compared GM, conventional and organic soybean production systems in terms of sustainability. The report concluded that all three systems could be environmentally sustainable and could be managed for profit. However, it pointed out that a high premium was needed for organic soybeans to compensate for lower yields and to ensure that the crop could be produced profitably.[71]

Scientific and medical resources

Transgenic Plants and World Agriculture

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- http://www.nap.edu/catalog/9889.html

American Medical Association (AMA)

- Report 10 of the AMA's Council on Scientific Affairs (I-00) "Genetically Modified Crops and Foods". Published December 2000. http://www.ama-assn.org/ama/pub/article/2036-4030.html

International Council for Science (ICSU)

- New Genetics, Food and Agriculture: Scientific Discoveries - Societal Dilemmas (June 2003). A synthesis of more than 50 science-based reviews, the report assesses the risks and benefits of applying new genetic discoveries to food and agriculture. The report was commissioned by ICSU's Advisory Committee on Genetic Experimentation and Biotechnology (ACOGEB). http://www.doylefoundation.org/icsu/index.htm

French Academy of Sciences

- Report in the safety of biotech food and crops, published December 2002. http://www.academie-sciences.fr/publications/rapports/rapports_html/rst13.htm

Union of the German Academies of Science and Humanities' Commission on Green Biotechnology

- Examination of the risks and safety of biotech food and crops, published September 2004. http://www.akademienunion.de/pdf/memorandum_green_biotechnology.pdf

New Zealand Royal Commission on Genetic Modification

- One of the longest and most thorough examinations of every aspect of biotech crops. http://www.mfe.govt.nz/issues/organisms/law-changes/commission/

Royal Society (London)

- Report on genetically modified plants for food use and human health - an update (Ref: 4/02), published February 2002. http://www.royalsoc.ac.uk/files/statfiles/document-165.pdf

British Medical Association

- Most recent (2004) statement on the safety and regulation of biotech foods. www.bma.org.uk/ap.nsf/Content/GMFoods

UK Government GM Science Review Panel

- Reports commissioned by the British government from its committee of experts during 2003 and 2004. http://www.gmsciencedebate.org.uk/report/default.htm

Council for Agricultural Science and Technology

- Numerous publications on the experiences of farmers dealing with agricultural biotechnology in crop and livestock production. http://www.cast-science.org/publications.asp

International Service for the Acquisition of Ag Biotech Applications

- Reports documenting the global spread of agricultural biotechnology applications. http://www.isaaa.org/.

PG Economics

- Numerous reports documenting the economic and environmental impacts of agricultural biotechnology crops around the world. http://www.pgeconomics.co.uk/

Science archives and background material

International Centre for Genetic Engineering and Biotechnology (ICGEB)

- Comprehensive bibliographic database on biosafety. Over 4,700 science and policy documents. http://www.icgeb.org/~bsafesrv/

ILSI International Food Biotechnology Committee

- International documents and scientific publications on plant biotechnology and the safety assessment of food products derived from plant biotechnology (September 2004). http://www.ilsi.org/file/Guide-Rev-Sep04.pdf

International Food Information Council – Food Insight

- A Useful Guide to Understanding GMOs, February 22, 2017 at https://foodinsight.org/a-useful-guide-to-understanding-gmos/. **National Academy of Sciences**
- Genetically Engineered Crops: Experiences and Prospects, May 17, 2016 at http://nas-sites.org/ge-crops/2016/05/17/report/. This is the latest of eleven reports the NAS has produced examining various aspects of GMO crops since 1986, all of which can be found here https://www.nap.edu/search/?term=GMO.

U.S. Regulatory Agencies Biotechnology Websites

- The principal U.S. regulatory agency for ensuring the safety of crops improved through biotechnology is the Biotechnology Regulatory Services Division of the Department of Agriculture (USDA). Detailed records and safety assessments of all U.S. field trials and regulatory approvals can be found here https://www.aphis.usda.gov/aphis/ourfocus/biotechnology.

The U.S. Food and Drug Administration (FDA)

- FDA consults with those proposing to put bioengineered foods on the market. A record of all those consultations can be found here https://www.fda.gov/food/submissions-bioengineered-new-plant-varieties/final-biotechnology-consultations.

The U.S. Environmental Protection Agency (EPA)

- The EPA regulates all biotech improved plants with pesticidal properties. Records can be found here https://www.epa.gov/pesticides/biopesticides#PIP.

AgBioForum (Journal of Agrobiotechnology, Management, & Economics)

- AgBioForum is a free online service which publishes short, non-technical articles on current research in agricultural biotechnology. It is financed by the Illinois Missouri Biotechnology Alliance (IMBA) which is supported by a Congressional Special Grant to provide funding for University biotechnology research. AgBioForum is edited at the University of Missouri-Columbia with the assistance of advising editors from all areas of its intended audience, including academia, private sector, government, and agribusiness media. http://www.agbioforum.org

Academics Review

- A website created by independent academics that applies standards of scientific peer review to safety claims about crops and foods, particularly biotechnology, that are widely circulated in the popular media. www.academicsreview.org

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