

ISAAA

MYTHS & FACTS ABOUT
Agricultural Biotechnology



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MYTH 1

So many resources are being devoted to GM crop research. These resources should instead be directed to organic farming or other ecological practices, because these practices and crops are proven safe.

THE FACT

There is no scientific data that proves organic farming to be safer than any other kind of farming. Nor is there data that proves farming GM crops to be unsafe. Farming biotechnology crops actually requires fewer resources than conventional farming.

Plant breeding in the early 1960s produced high-yield varieties of major food crops, resulting in yield increases but also significant displacement of traditional varieties and a concomitant loss in genetic diversity, particularly landraces of cereals and legumes."[1]

Organic and biotech farming can contribute solutions to various agricultural problems. "Organic production relies on practices, such as cultural and biological pest management, that can include IPM and biological control but excludes the use of synthetic chemicals and GE organisms. The use of GE organisms can also contribute to sustainable practices by augmenting and replacing certain conventional practices. For example, plants can be created that increase water use and fertilizer efficiencies, that remediate soil contaminants, increase no-till or low-till practices to help reduce greenhouse gases, and produce higher yields without increasing land usage, particularly in developing countries."[2]

1 Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, 2.3. Could the Use of Genetically Engineered Crops Result in a Loss of Plant Biodiversity?

2 Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, 2.17. Can Use of Genetically Engineered Crops or Organic Farming Lead to More Sustainable Agricultural Production Systems?

In 2014, a "cumulative hectarage of more than 1.7 billion hectares of biotech crops have been successfully cultivated."[3] As of March 2013, 37,245,686 hectares of land were organically farmed.[4]

Conventional farming uses pesticides and herbicides to protect crops, but biotechnology farming significantly reduces the use of such chemicals.

"Biotechnology saves the equivalent of 521,000 pounds of pesticides each year and helps cut herbicide runoff by 70 percent."[5]

Planting biotech crops can lead to more efficient — and therefore safer and more cost-effective — agricultural practices overall. "Having crops tolerant to herbicides and pest attack increases pest management options and can also reduce the number and strength of pesticide applications."[6]

3 ISAAA Brief 49-2014: Top Ten Facts. http://isaaa.org/resources/publications/briefs/49/topfacts/default.asp
4 Development of all organic areas (including conversion land) country and region 2005-2011. Research Institute of Organic Agriculture FiBL and International Federation of Organic Agriculture Movements IFOAM. Published at Organic-World.net, maintained by FiBL, Frick, Switzerland, http://www.organic-world.net.
5 10 Reasons We Need Biotech Foods and Crops, Genetic Literacy Project
6 Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, 2.7. Does the Use of Genetically Engineered Crops Result in Decreased Use of Pesticides

Professional and independent organizations such as the Organization for Economic Cooperation and Development (OECD) and US National Research Council of the National Academies of Science (NRC) have been conducting comprehensive scientific analyses of risks associated with various aspects of biotechnology since 1986. The risks of biotechnology crops are the same as those produced by conventional breeding.[7]

Farming with biotech crops is sustainable. "GM crops in general need fewer field operations, such as tillage, which allows more residue to remain in the ground, sequestering more CO2 in the soil and reducing greenhouse gas emissions."[8] In 2013 alone, these practices reduced "CO2 emissions by 28 billion kg, equivalent to taking 12.4 million cars off the road for one year."[9]

There is no scientific data to support the idea that organic food is any safer than regular food.[10]

7 Review: Public perceptions of biotechnology, by Alan McHughen, 4.1 Media issues
8 10 Reasons We Need Biotech Foods and Crops, Genetic Literacy Project
9 ISAAA Brief 49-2014: Top Ten Facts. http://isaaa.org/resources/publications/briefs/49/topfacts/default.asp
10 Review: Public perceptions of biotechnology, by Alan McHughen, 4.1 Media issues

MYTH 2

The genetic engineering of crops is not natural. That type of genetic modification probably does not happen naturally.

THE FACT

Genetic modification happens naturally. Farmers have been cross-breeding plants for centuries, depending on trial-and-error to get the desired results. Biotechnology is a safer, more deliberate way of achieving—and replicating—the desired results.

Genetic modification is perpetually taking place naturally, even without human intervention. "Most plants reproduce via self-fertilization or movement of genes from one parent to another via pollen. This process is an essential tenet of genetic diversity. But movement of unwanted genes, naturally occurring or engineered, may result in adventitious presence, a situation where unwanted substances unavoidably are present in production and marketing of agricultural products."[11]

Genetic engineering between non-related organisms happens naturally, but can take a "very long evolutionary timeframe." Biotechnology can speed up the process, examine how it takes place, how it would be beneficial or harmful, and what would be required for the resulting organism to survive.[12]

Biotechnology uses recombinant DNA (rDNA) methods to develop modifications in crops. Just like classical breeding, this can involve changes in the sequence, order and regulation of genes and use many of the same enzymes. But classical breeding involves all the tens of thousands of genes that exist in the organism. With rDNA methods, the modifications can be limited to only a few genes. These very precise methods can even indicate when and where in the organism's development the modification will take place. This precision is difficult to achieve with classical breeding methods.[13]

[11] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 2.14. What Happens When Pollen Moves From Genetically Engineered Crops to Wild Relatives or Non-Genetically Engineered Varieties? In Areas of Genetic Diversity?

[12] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 2.11. Can Genes From Genetically Engineered Plants Move to Bacteria in the Field?

[13] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 2.3. How Does the Creation of a Genetically Engineered Crop Differ from That of a Classically Bred Crop?

Classical breeding methods can only cross genes of closely related organisms. But rDNA methods can use genetic material from any living organism and introduce the DNA into plants. This is why *Bacillus thuringiensis* (Bt) can be used in corn, cotton and eggplant.[14]

Conventional breeding can make use of marker-assisted selection (MAS). The genes or sequences responsible for specific plant traits can be identified, thus assisting in the selection of breeds to be crossed.[15]

"Transgenic crops are subjected to a thorough safety assessment that includes a demonstration of required genetic stability prior to approval. Conventionally bred and organic crops that carry far more mutations are not subjected to safety review."[16]

"GM crops are tested in greenhouses and experimental fields in order to evaluate a number of factors such as performance, the proper function of the newly introduced trait, and that the trait is stably inherited."[17]

[14] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 2.3. How Does the Creation of a Genetically Engineered Crop Differ from That of a Classically Bred Crop?

[15] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 2.4. Can Marker-Assisted Selection Be Used Instead of Genetic Engineering to Improve Crops?

[16,17] Genes rearrange naturally all the time with no ill effects. http://academicsreview.org/reviewed-content/genetic-roulette/section-4/4-3-genes-rearrange/

MYTH 3

Field trials of biotech crops are dangerous. There is a high risk of contaminating other, non-biotech crops in nearby fields.

THE FACT

Field trials are conducted under very strict conditions and follow stringent regulations. These conditions include the prevention of pollen flow and the prevention of entry into food and feed pathways. The failure to comply with any single condition or regulation means the trial will be stopped.

The Cartagena Protocol on Biosafety to the Convention on Biological Diversity has been ratified by 167 countries as of March 2014.[18] According to the Cartagena Protocol, field trials and all other activities involving genetically modified organisms must be regulated and approved by national governments.[19] This means that in any country that is party to the protocol, any field trial that is being conducted has already been scrutinized and approved by the government.

18 The Cartagena Protocol on Biosafety. http://bch.cbd.int/protocol/default.shtml
19 Confined field trials in Africa: a key step to safely perform experiments with genetically modified crops. Dr. Moussa Savadogo, Program Officer, ABNE. NEPAD - AFRICAN BIOSAFETY NETWORK OF EXPERTISE (NEPAD-ABNE) http://www.nepadbiosafety.net/abne/wp-content/uploads/2010/10/Env.-Biosafety-Policy-Brief-N0-2.pdf

The possibility of unintentional cross-breeding is not unique to biotech crops. Genes move between plants all the time, with both conventional and biotech crops. "Many major agricultural crops are sexually compatible with wild and/or weedy relatives, and, if the plants grow in overlapping regions, crop-to-weed or crop-to-wild relative gene flow could result. This outcrossing to wild populations can result in new combinations of genes that can improve, harm, or have no effect on the fitness of recipient plants. Genes can also flow from wild relatives to cultivated crops, introducing new traits into next generation seed, but only affect the crop if it is replanted."[20]

Some plants have a natural, strong tendency towards outcrossing,[21] and researchers study the factors that affect this, such as species, location and trait. "This type of information can be used to establish distances and practices to minimize gene flow."[22]

20 Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux. 2.14. What Happens When Pollen Moves From Genetically Engineered Crops to Wild Relatives or Non-Genetically Engineered Varieties? In Areas of Genetic Diversity?
21 Outcrossing: process by which plants reproduce by dispersing their pollen to other compatible plants, rather than self-pollinating. Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux.
22 Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux. 2.14. What Happens When Pollen Moves From Genetically Engineered Crops to Wild Relatives or Non-Genetically Engineered Varieties? In Areas of Genetic Diversity?

Field trials conducted in countries all over the world observe strict conditions. GM crops are tested in confined field trials (CFTs). "Because GM crops contain one or several additional genes than the conventionally bred crops, their field-testing is carried out under conditions to ensure that the materials tested remain within the trial site; and hence, are referred to as confined field trials (CFTs). Since CFTs are conducted in an open field, scientists design them to prevent the escape of the new genes and other plant material outside the experimental sites. While CFTs allow scientists to collect data on the performance of a particular GM crop, they can also be used to demonstrate the new technology to farmers and other stakeholders. Generally, CFTs are conducted under the responsibility of scientists from public or private research institutions. These trials are usually carried out on a small scale, often on not more than one hectare area, at experimental stations such as those under the control of national agricultural research systems (NARS), local universities, or private sector research units. Such institutions are staffed by competent scientists with sound experience in the safe conduct of field trials and have capacity to evaluate the performance of new varieties for farmers."[23]

In the Philippines, field trials are conducted under the strict supervision of the NCBP, the local Institutional Biosafety Committee (IBC) and the Bureau of Plant Quarantine under the Department of Agriculture.

There are three stages:[24]

1. Contained trial is done in a facility approved by the NCBP to observe the characteristics gene modification;
2. Limited confined field trial is conducted in one location only, and demonstrates the effectiveness of the gene inserted into the GM crop, under the supervision of NCBP Institutional Biosafety Committee;
3. Multi-location field trials are conducted in several locations for two farming seasons, to review environmental risk assessment according to the regulations of the Department of Agriculture-Bureau of Plant Industry (DA-BPI). The environmental risk assessment reviews efficacy, yield trials, unintended effects, and impact on non-target organisms.

23 Confined field trials in Africa: a key step to safely perform experiments with genetically modified crops. Dr. Moussa Savadogo, Program Officer, ABNE. NEPAD - AFRICAN BIOSAFETY NETWORK OF EXPERTISE (NEPAD-ABNE) http://www.nepadbiosafety.net/abne/wp-content/uploads/2010/10/Env.-Biosafety-Policy-Brief-N0-2.pdf

24 Email interview, June 24, 2014, Dr. Lourdes D. Taylo, Entomology Laboratory, Institute of Plant Breeding, Crop Science Cluster, UP Los Baños College, Laguna

For each pre-approved trial site, the product developer is issued a Field Trial Permit. The developer must comply with the conditions indicated on the permit. Those conditions are required in order to mitigate the potential risks that any GM crop may do to the environment.

These conditions are:

- prevent pollen flow ("contamination" or cross-pollination right term);
- prevent persistence or weediness; and
- prevent entry into food and feed pathway.
- Failure to comply with any one of the conditions means stoppage of the trial.[25]

[25] Email interview, June 24, 2014, Dr. Lourdes D. Taylo, Entomology Laboratory, Institute of Plant Breeding, Crop Science Cluster, UP Los Baños College, Laguna

MYTH 4

Field trials of biotech crops are made to appear successful but the results are falsified. Field trials have successful results due to the use of additional fertilizer and less pesticide.

THE FACT

Field trials are conducted to compare GM crops with non-GM counterparts, and provided similar agricultural management except for the one related to the transgenic trait. All data from biotechnology crop research—from the research proposal to the field trials—are reviewed, vetted and signed by panels of technical experts, quarantine officers, project personnel and Institutional Biosafety Committees (IBC). If any stage of the experiment appears dubious in any way, the experiment is stopped.

The pesticides and herbicides required by a biotech crop depend on the plant trait that has been modified. In the case of plants modified with *Bacillus thuringiensis* (Bt), the modification will only protect the plants from insects that are susceptible to the protein Bt, such as the fruit and shoot borer (FSB), corn borer, and rice stem borer. There are other insects which will not be affected by Bt, and thus other solutions are required to protect the crops from these insects. "Even with GE approaches, other methods of insect control may be needed, e.g., chemical pesticides, biocontrol, integrated pest management, or organic approaches, because insects varied, plentiful and ever changing." [26]

[26] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, 2.8. Is It True that Bt Crops Need Additional Insecticide Applications?

[27] Email interview, 2014 Dr. Lourdes D. Taylo, Entomology Laboratory, Institute of Plant Breeding, Crop Science Cluster, UP Los Baños, College, Laguna

"As scientists, our job is to know exactly and measure the performance of the GM crop for effectiveness against the target insect pest, measure yield advantage and determine the impact of the Bt protein to the non-target organisms across locations and seasons. The conduct of any experiment starts with a research proposal to be evaluated by panel of technical expert scientist. Once approved, a meeting is set up between the proponents and Plant Quarantine Office to discuss in detail the type of data to be collected, calendar of activities and schedule of monitoring by Plant Quarantine Officer. At the end of each observation, data sheets are signed by the present project personnel and attested by assigned plant quarantine officer and IBC member and submitted afterwards. So there is no way that data are tampered.

Establishment and crop maintenance or cultural management of GM crops are done the same way that a non-GM crop is planted—fertilizer application, weeding, tillage. Plants are laid out in Randomized Complete Block Design with proper replications to measure the variation due to treatment effects and sources of variation (soil gradient and nutrients). Most importantly the plant materials used: Bt, non-Bt and non-Bt check variety as the conduct of risk assessment for GM crops is always comparative. The Plant Quarantine Officer and IBC member strictly monitor our compliance. No viable plant materials are left in the field. Fruits are boiled, chopped and buried while during termination, all plants are uprooted, chopped and buried in a pit inside the trial site." [27]

In the Philippines, results obtained from the two-year multi-location field testing indicate that the UPLB eggplant open pollinated lines and F1 hybrids containing transgenic event ‘EE-1’

a. possess a novel trait that provided outstanding control of EFSB, making them superior to the conventional counterparts and the check, particularly when pest pressure is high;
b. have no demonstrated adverse effects on non-target organisms, particularly beneficial non-target arthropods;
c. have comparable horticultural and phenotypic characteristics and reactions to eggplant diseases and other pests compared to that of convetional eggplant control, and therefore, are not likely to pose any increased plant pest risks;
d. demonstrated high-dose field efficacy diminishing reproductive irrelevant plants.”

[28] Hautea, RA, DM Hautea, RB Quilloy, LD Taylo and MV Navasero. 2015. Support to multi-location field trial and commercialization of open-pollinated and hybrid varieties of Bt eggplant in the Philippines (Phase 2) Terminal Report submitted to DA-Biotech Program Office.

MYTH 5

Planting biotech crops harms the environment. We don't know what effects these crops will have on the environment in ten or twenty years.

THE FACT

Current farming practices, including the use of pesticides and herbicides, are very harmful to the environment, and to human health—of farmers and consumers—as well. Biotech crops that are designed to be pest-resistant will significantly reduce the use of pesticides and herbicides, thus reducing the risk to the environment and to human health.

Biotechnology can actually contribute to the environment though the development of alternative energy sources.[29]

Nobel laureate Dr. Norman Borlaug, creator of the World Food Prize, supported the use of biotechnology to save the environment and improve food security. "Biotechnology, he stressed, will help preserve the ecosystem while also reducing hunger and malnutrition, by providing these increased yields. In that way, he may be saving more trees as a plant pathologist than he even would have as a forest ranger."[30]

Since 1996, biotech crops have reduced the amount of pesticides used by 497 million kilograms. In 2013 alone, fewer insecticide and herbicide sprays reduced CO2 emissions by 28 billion kilograms, equivalent to taking 12.4 million cars off the road for a year.[31]

Brookes and Barfoot (2014) found that "The global insecticide savings from using GM IR maize and cotton in 2012 were 7.6 million kg (-86.5% of insecticides typically targeted at maize stalk boring and rootworm pests) and 16.8 million (-40% of all insecticides used on cotton), respectively of active ingredient. From 1996-2013, the gains have been a 58 million kg reduction in maize insecticide active ingredient use and a 205 million kg reduction in cotton insecticide active ingredient use."[32]

29 Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 2.9. What Is in the Crop Biotechnology Pipeline?

30 Dr. Norman Borlaug, creator of the World Food Prize, Nobel Laureate, http://www.worldfoodprize.org/en/dr_norman_e_borlaug/extended_biography/

31 ISAAA Brief 49-2014: Top Ten Facts. http://isaaa.org/resources/publications/briefs/49/topfacts/default.asp

32 Barfoot, P. and Brookes G. 2014. Key global environment impacts of genetically modified (GM) crop use 1996-2012, GM Crops and Food: Biotechnology in Agriculture and the Food Chain, 5:2, 149-160, DOI: 10.4161/gmcr.28449

Planting herbicide-tolerant crops not only reduces spraying of pesticides, but also reduces the need for the mechanical removal of weeds, “both of which can damage crops and result in environmental damage. Reducing mechanical tillage lowers fuel consumption and helps conserve soils prone to erosion and compaction. HT crops can also lead to more flexible herbicide treatment regimes.”[33]

[33] Genetically Engineered Plants and Foods: A Scientist’s Analysis of the Issues (Part II), Peggy G. Lemaux, 2.7. Does the Use of Genetically Engineered Crops Result in Decreased Use of Pesticides?

GE crops resulted in significant reductions in the global environmental impact (EI) of production agriculture. “Since 1996 the overall EI associated with pesticide use on HT soybean, corn, cotton, canola, and Bt cotton decreased by 15.3%.” Environmental Impact Quotient (EIQ) “measures environmental and toxicological effects on the basis of many variables: toxicity of the active ingredient (AI), its mode of action, period of time AI persists, and ability of herbicide to contaminate groundwater. Each AI in a pesticide has a specific EIQ based on these parameters.”[34]

Glyphosate tolerant crops may provide safety and environmental benefits. They have helped the widespread adoption of no-tillage farming in North and South America, saving soil, water, diesel fuel, herbicide run-off, and carbon emissions. Reduced use of other herbicides than glyphosate, for instance, imazethapyr, chlorimuron, pendimethalin, and trifluralin on soybeans (CASTS 2004), made possible by transgenic glyphosate tolerant soybean varieties, reduces potential health hazards from herbicide contamination.”[35]

[34] Genetically Engineered Plants and Foods: A Scientist’s Analysis of the Issues (Part II), Peggy G. Lemaux, 2.7. Does the Use of Genetically Engineered Crops Result in Decreased Use of Pesticides?

[35] New herbicide-tolerant crops help the environment, reduce agricultural impact. http://academicsreview/reviewed-content/genetic-roulette/section-6/6-2-new-herbicide-tolerant-crops/

MYTH 6

Seed companies control the sale and use of biotech seeds. They force farmers to buy expensive seeds, and sue farmers who plant biotech crops without their permission. Biotech crops just make poor farmers poorer and the seed companies richer.

THE FACT

More than 90% or over 18 million farmers that grew biotech crops in 2014 are small, resource-poor farmers in developing countries. The unprecedented increase in number of farmers planting biotech crops shows that biotech crops deliver substantial, sustainable, socio-economic and environmental benefits. In all cases farmers are given the freedom to choose which types of seeds they wish to plant.

Many farmers all over the world have tried planting biotech crops and found it preferable to their previous crops. This is happening in Asia, and even in Europe, specifically in France. "In 2005, a handful of tentative French farmers were allowed to grow a mere 500 hectares of GM corn under government supervision. In 2006, the area increased 10-fold, and intentions for 2007 estimate another 6- to 10-fold increase, for a total of 60-100-fold increase over just 2 years… According to the same report, the benefits enjoyed by the French farmers included a 9-12% yield increase and a dramatic drop in toxic fumonisin content."[36] Among the toxic effects of fumonisins are "elevated rates of liver and/or esophageal cancer."[37]

The global hectarage of biotech crops have increased more than 100-fold in 18 years, from 1.7 million hectares in 1996 to over 181 million hectares in 2014. This makes biotech crops the fastest adopted crop biotechnology in recent history.[38]

36 Review: Public perceptions of biotechnology, by Alan McHughen, 6 Who benefits?

37 Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 2.8. How Many Foods Are Genetically Engineered?

38 ISAAA Brief 49-2014: Executive Summary. Global Status of Commercialized Biotech/GM Crops: 2014 http://isaaa.org/resources/publications/briefs/49/executivesummary/default.asp

Spain is the only EU member country growing a biotech crop—Bt corn—in a substantial amount of land. A 2007 study examined who benefited the most from the crop. "The largest share of welfare (value) created by the introduction of Bt maize (i.e., corn) (74.4 % on average) went to Bt maize farmers and the rest went to the seed companies (25.6% on average), taken to include seed developers, seed producers and seed distributors".[38]

39 Review: Public perceptions of biotechnology, by Alan McHughen, 6 Who benefits?

Farmers with greater income mean farmers with healthier families. In India, the increase in the number of farmers adopting GM cotton has been linked to increased calorie consumption and reduced undernourishment in families. If all non-Bt farmers in India adopt the same technology, food insecurity could drop by 15-20%.[40]

Mycotoxins are produced by micro fungi and can cause disease and death in humans and other animals.[41] Bt corn has significantly fewer mycotoxins than conventional corn, and this has economic consequences. "Bt reduces insect damage on kernels, thus reducing infection by mycotoxigenic fungi." Grain with insect damage can lead to economic losses, which "are due to market rejection of contaminated grain, export market losses, and testing costs. A literature review in 2007 concluded that economic benefits of Bt maize in reducing the mycotoxins, fumonisin and aflatoxin, were ~$22M and $14M, respectively. Mycotoxins are a significant health issue where unprocessed corn is a dietary staple, and thus, health benefits from mycotoxin reduction are particularly important in developing countries."[42]

Although current biotech crops are not engineered for higher yield, "increased yields have been observed. This higher yield has been demonstrated in numerous studies and surveys of HT corn, Bt cotton, and Bt corn. Data analysis of the USDA Economic Research Service's (ERS) Agricultural and Resource Management Surveys of 2001 to 2003 showed that most farmers, e.g., 79% of those choosing Bt corn, adopted GE varieties to increase yields through improved pest control. Other reasons included time savings and ease of agricultural practices."[43]

40 10 Reasons We Need Biotech Foods and Crops, Genetic Literacy Project
41 US National Library of Medicine, National Institutes of Health, Mycotoxins, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC164220/
42 Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, 3.1. Why Do Farmers Plant Genetically Engineered Crops and Who Profits From Them?
43 Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, 3.1. Why Do Farmers Plant Genetically Engineered Crops and Who Profits From Them?

MYTH 7

Biotech crops are responsible for the evolution of “super bugs” and “killer weeds.” Pests and weeds evolve or adapt to overcome the crop’s genetic modification.

THE FACT

Excessive and irresponsible use of existing pesticides and herbicides are responsible for the evolution of “super bugs” and “killer weeds.” Adaption of pests and diseases to resistance genes occur in both conventionally-bred and GM lines, but with compliance to resistance management, this phenomenon can be minimized.

The problem of weeds resistant to herbicides occurs with both traditionally bred and biotech crops. So called "superweeds" arose because of the overuse of herbicides, or because of "movement of conventional herbicide-tolerance traits to weedy species, resulting in plants not controllable with previously applied herbicides."[44] The overuse of single herbicides can lead to the growth of resistant weeds. As with the insect resistance, "alternate modes of action that can be used in rotation will slow resistance development in weeds."[45]

Bacillus thuringiensis (Bt) in the form of sprays has been used to "control insects since the early 1920s, but use of specific Bt toxins has increased dramatically since 1996 with the introduction of GE crops."[46]

It is only natural that insects evolve resistance Bt toxins, just as they evolved to resist synthetic insecticides and Bt toxins in sprays. "The elapsed time before the first cases of field resistance of insects to Bt crops were reported and has been longer than what was predicted under worst-case scenarios, suggesting that management strategies may have delayed resistance development. Despite documented cases of resistance, Bt crops remain useful against most target pests in most regions.[47]

[44,45] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, 2.5. Will the Use of Herbicide-Tolerant Genetically Engineered Crops Lead to Superweeds?

[46,47] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, 2.1.Will the Widespread Use of Bt Crops Lead to the Development of Insect Resistance to Bt?

The U.S. Environmental Protection Agency (EPA) closely monitors fields where Bt crops are grown, to watch for resistance to Bt. Bt cotton has been grown in Arizona since 1997, and a statewide surveillance system has been observing the pink bollworm for resistance. “From 1997 to 2004, results of laboratory bioassays of insects derived annually from 10 to 17 cotton fields statewide showed no net increase in mean frequency of pink bollworm resistance to Bt toxin. DNA screening from 2001 to 2005 also showed that resistance-linked mutations remained rare in pink bollworm field populations.”[48]

Scientists frequently study the effects of biotech crops on non-target organisms. No evidence has been found to indicate that biotech crops will have adverse effects on non-target organisms. “To ‘encourage evidence-based risk analysis,’ Marvier et al. published a report in 2007 describing a searchable database on the effects of Bt on nontarget insects. In a meta-analysis of 42 field experiments, taking into account location, duration, plot sizes, and sample sizes, these authors concluded that (a) the mean abundance of all non-target invertebrate groups, in terms of numbers, survival, and growth, was greater in Bt cotton and Bt maize fields than in non-Bt fields managed with insecticides but, (b) if Bt crop fields and insecticide-free fields were compared, certain non-target insects were less abundant in Bt fields... In general, although numbers and types of microbes and enzyme activities differed from season to season and among varieties, no statistically significant differences were seen in numbers of different microbes, enzyme activities, or pH between soils with Bt and non-Bt corn.

In similar studies comparing impacts on the rhizosphere of Bt cotton versus non-Bt cotton, various enzymatic activities were measured before and after harvest. The authors concluded that richness of the microbial communities in the rhizosphere did not differ between Bt and non-Bt cotton. No Cry2Ab protein was detected in the rhizosphere soil of field-grown Bt rice.”[49]

48 Genetically Engineered Plants and Foods: A Scientist’s Analysis of the Issues (Part I), Peggy G. Lemaux, 3.4. Are Food Safety Studies Conducted on GE Foods? 2.1.Will the Widespread Use of Bt Crops Lead to the Development of Insect Resistance to Bt?

49 Genetically Engineered Plants and Foods: A Scientist’s Analysis of the Issues (Part II), Peggy G. Lemaux, 2.2. Can Genetically Engineered Crops Cause Adverse Effects on Nontarget Organisms?

MYTH 8

Foods made with biotech crops are not safe for human consumption. They cause allergies, cancer, homosexuality and birth defects, as well as many other negative side effects.

THE FACT

Foods made with biotech crops have been in the market for years, and are as safe or unsafe as traditional crops. Rigorous testing is done on all biotech crops before they are even commercialized. If they have been approved for commercialization then they have been proven safe to eat.

Independent research conducted over the past 25 years have found no evidence of negative effects on health nor evidence of deaths caused by the consumption of foods made with biotech crops.[50]

Foods and products made with biotech crops undergo safety testing by the institutions that develop them. From there the data is usually reviewed by agencies with authority to approve them for cultivation or commercialization. The foods and products themselves are also tested rigorously by independent researches, with the results published in peer-reviewed journals to invite additional scrutiny. All products that have been approved for sale on the market undergo “full review by regulatory agencies regarding safety and content” as compared to their conventionally grown counterpart crops. The process is comparable to the safety assessments performed for pharmaceuticals.[51]

50 10 Reasons We Need Biotech Foods and Crops, Genetic Literacy Project

51 Genetically Engineered Plants and Foods: A Scientist’s Analysis of the Issues (Part I), Peggy G. Lemaux, 3.4. Are Food Safety Studies Conducted on GE Foods?

Risk assessment procedures for biotech crops also check if the modification changed anything else in the organism. This comparison between the GE crop and its unmodified counterpart is known as substantial equivalence. “The GE crop is assessed for agronomic, morphological and chemical characteristics, such as macro and micro-nutrients, anti-nutrients and toxic molecules. The results of this analysis will provide information on the necessity for further analysis of the nutritive value. Any difference which falls within the range of the normal variability for the crop is considered safe. This methodology has been agreed internationally (Codex, FAO, OECD, WHO)... The principle of substantial equivalence has been used for risk assessment of the GE crops commercialized so far and the results support the fact that these crops are equivalent to their nontransgenic counterparts.”[52]

Transgenes represent a very small amount of the total DNA in a genetically engineered plant. When a plant is consumed, only fragments of the plant’s DNA reach the human digestive system, where it is broken down further. This is true whether the plant is genetically engineered or not. Decades of research have shown that dietary DNA is safe and even beneficial to human health. “Humans typically consume a minimum of 0.1 to 1 gram of DNA in their diet each day (Doerfler, 2000). Therefore, the transgene in a genetically engineered plant is not a new type of material to our digestive systems, and it is present in extremely small amounts. In transgenic corn, the transgenes represent about 0.0001% of the total DNA (Lemaux and Frey, 2002).

Decades of research indicate that dietary DNA has no direct toxicity itself. On the contrary, exogenous nucleotides have been shown to play important beneficial roles in gut function and the immune system (Carver, 1999). Likewise, there is no compelling evidence for the incorporation and expression of plant-derived DNA, whether as a transgene or not, into the genomes of consuming organisms.”[53]

52 An overview of the last 10 years of genetically engineered crop safety research. Alessandro Nicolia, Alberto Manzo, Fabio Veronesi, and Daniele Rosellini.

53 SOCIETY OF TOXICOLOGY POSITION PAPER. The Safety of Genetically Modified Foods Produced through Biotechnology. TOXICOLOGICAL SCIENCES 71, 2–8 (2003) by the Society of Toxicology

Biotechnology can be used to alter the nutritional profile of foods. There are foods that have been modified for "increased β-carotene, flavonoids, calcium, folate, and iron availability." In such cases the modified foods will undergo assessment as well. "According to [US] FDA policy, GE foods with altered nutritional traits must be labeled to indicate nutritional differences; one example is Vistive™, a low-linoleic oil from GE soybeans that can be used instead of transfat–containing oils."[54]

Biotechnology has also developed plants that can be used in combating human diseases. Examples include "the development of a subunit vaccine against pneumonic and bubonic plague; a potato-based vaccine for hepatitis B; aGE pollen vaccine that reduces allergy symptoms; and an edible rice-based vaccine targeted at alleviating allergic diseases such as asthma, seasonal allergies, and atopic dermatitis."[55]

[54] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 3.6. Do Genetically Engineered Foods Have Changes in Nutritional Content?

[55] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 2.9. What Is in the Crop Biotechnology Pipeline?

MYTH 9

Biotech crops are not safe for animal consumption either. Farm animals that eat biotech crops get sick and even die. Animals in lab tests were shown to have died from eating biotech foods.

THE FACT

Biotech crops have been used for feeds for more than 18 years and there is no record of sickness or fatality.

A significant number of studies on biotech crops conducted in the past 10 years focus on their use as food and feed. "According to the literature, the concerns about GE food/feed consumption that emerge from the scientific and social debates can be summarized as follows: safety of the inserted transgenic DNA and the transcribed RNA, safety of the protein(s) encoded by the transgene(s) and safety of the intended and unintended change of crop composition (Dona & Arvanitoyannis, 2009; Parrot et al., 2010)."[56]

Biotech crops in animal feed are safe for animals and for the humans who consume products derived from those animals. "The consumption of transgenic proteins contained in the authorized GE crop does not result in any detectable systemic uptake (Kier & Petrick, 2008) and transgenic proteins are usually rapidly degraded and not detectable in animal derived products (e.g. milk, meat, eggs)."[57]

[56] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 3.5. What Happens to the DNA in Foods When They Are Eaten?

[57] An overview of the last 10 years of genetically engineered crop safety research. Alessandro Nicolia, Alberto Manzo, Fabio Veronesi, and Daniele Rosellini. Interaction of GE crops with humans and animals (GE food&feed)

Consuming feeds made with biotech crops will not affect animals negatively. In July 2007, the European Food Safety Authority released statements on the fate of genes and proteins in food and feed: "After ingestion, a rapid degradation into short DNA or peptide fragments is observed in the gastrointestinal tract of animals and humans" and "To date a large number of experimental studies with livestock have shown that rDNA fragments or proteins derived from GM plants have not been detected in tissues, fluids or edible products of farm animals."[58]

Many studies have reviewed and published animal tests on biotech foods. The studies report "both chemical analyses and studies in a variety of animals (e.g., dairy cows, beef cattle, pigs, laying hens, broilers, fish, and rabbits) revealed no significant, unintended differences between GE and conventional varieties in composition, digestibility, or animal health and performance. The lack of significant differences between GE food and feed and isogenic counterparts in these tests strongly supports their substantial equivalence."[59]

[58] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 3.5. What Happens to the DNA in Foods When They Are Eaten?

[59] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I), Peggy G. Lemaux, 3.4. Are Food Safety Studies Conducted on GE Foods?

The use of Bt corn for animal feed is beneficial to animal health. Bt corn has reduced mycotoxins, which have a variety of negative health effects in animals. Mycotoxins are produced by micro fungi and can cause disease and death in humans and other animals.[60] "The most prevalent impacts are due to aflatoxin, with lesser effects from Fusarium mycotoxins, or fumonisins, and deoxynivalenol (DON) also called vomitoxin because it induces vomiting and hemolysis of erythrocytes in animals. These compounds are known to cause a variety of short- and long-term health effects. Bt reduces insect damage on kernels, thus reducing infection by mycotoxigenic fungi."[61]

60 US National Library of Medicine, National Institutes of Health, Mycotoxins, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC164220/

61 Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II), Peggy G. Lemaux, 3.1. Why Do Farmers Plant Genetically Engineered Crops and Who Profits From Them?

MYTH 10

Nutritionally-enhanced biotech rice and other crops is not the best way to solve the nutrient deficiency problem. Other, more effective solutions are already in place. Micronutrient deficiency is not even a big public health issue anymore.

THE FACT

Nutritionally-enhanced biotech crops are being promoted as a supplementary solution to nutrient deficiency, to be used in conjunction with other methods that are already in place. Global micronutrient deficiency is a health and nutrition issue which result to susceptibility to infectious diseases, mental retardation and child mortality.

Micronutrient deficiency such as Vitamin A deficiency is a serious health problem, especially in developing countries. "Vitamin A deficiency, along with iron and zinc deficiencies, pose the greatest public health consequences of all micronutrient deficiencies. Vitamin A deficiency is most common in young children and pregnant women and can lead to blindness, susceptibility to infectious diseases, and death. The Food and Agricultural Organization and the United Nations have developed different strategies to overcome deficiency of vitamin A, including dietary diversification, food fortification, and vitamin supplementation. When applied, there has been varying success in different regions of the developing world with the various approaches... All these efforts required continuous public education and financial support from the public and private sector. For example, vitamin A fortification of sugar was temporarily suspended owing to an economic downturn that increased vitamin A prices and at that point vitamin A deficiency reappeared. Recent studies indicate that biofortification, i.e., incorporating micronutrients into food, has the potential to control deficiencies and is cost-effective and efficient compared with alternative public health and agricultural measures when coupled with other micronutrient interventions."[62]

[62] Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II). Peggy Lemaux. 3.21. Is Golden Rice the Only Way to Provide Vitamin A to People in Developing Countries?

Golden Rice (GR), a genetically modified rice, is an example of micronutrient staple. GR was developed to "complement other existing approaches to address vitamin A deficiency... In the Philippines, vitamin A deficiency affects approximately 1.7 million children (15.2%) aged 6 months to 5 years. Subclinical vitamin A deficiency affects one out of every ten pregnant women." Vitamin A deficiency can be avoided with a balanced diet that includes "fresh fruits and vegetables and with animal products such as eggs, liver, cheese, and whole milk" which contain beta carotene. Beta carotene is converted to vitamin A when eaten. But impoverished families have limited access to such a diet. Rice being the staple food of Filipinos and many other Asians, augmenting it with beta carotene can assist in alleviating vitamin A deficiency. Adequate amounts of vitamin A also reduce overall child mortality from common illnesses (including measles, severe pneumonia, and persistent diarrhea)[63] by 23-34%.[64]

[63] http://irri.org/golden-rice/faqs/why-is-golden-rice-needed-in-the-philippines-since-vitamin-a-deficiency-is-already-decreasing

[64] Golden Rice: using agricultural biotechnology for nutrition. IRRI. http://irri.org/blogs/item/golden-rice-using-agricultural-biotechnology-for-nutrition

β-carotene derived from Golden Rice is effectively converted to vitamin A in healthy human adults, as proven by clinical trials. Results published in 2009 show that Golden Rice β-carotene was effectively converted to vitamin A among all the subjects. "Altogether, our results show that the conversion factor of Golden Rice β-carotene to retinol is 3.8 ± 1.7 (mean ± SD) to 1 with a range of 1.9–6.4 to 1 by weight, or 2.0 ± 0.9 to 1 with a range of 1.0–3.4 to 1 by mol. The conversion factors between men (n ¼ 2) and women (n ¼ 3) were not different. In addition, in these 5 subjects, there was no correlation between the conversion factors and BMIs." Furthermore, no adverse effects were observed in the subjects after consuming GR. "It should be noted that we closely monitored our subjects for any possible adverse effects after the consumption of Golden Rice and found no evidence of any problems, including allergic reactions or gastrointestinal disturbance."[65]

In 2004, a survey in China determined that Vitamin A deficiency was common problem among both urban and rural populations. "The prevalence of vitamin A deficiency among the children aged between 3 and 12 years old was 9.3%, among which in the urban areas it was 3.0% and in rural areas the figure was 11.2%; the prevalence of marginal vitamin A deficiency was 45.1%, among which in the urban areas it was 29.0% and in the rural areas the figure was 49.6%."[66] Researchers conducted a study to compare the vitamin A value of Golden Rice compared to other sources of vitamin A, namely spinach and pure beta carotene oil. "Here we report a trial to determine the vitamin A value of intrinsically labeled GR compared with spinach (a representative, household-grown, dark-green leafy vegetable that is rich in β-carotene and is commonly eaten by Chinese children) or pure β-carotene in oil, by using schoolchildren of marginal or normal vitamin A status... The study was carried out in an elementary

65 Golden Rice is an effective source of vitamin A. Guangwen Tang, Jian Qin, Gregory G Dolnikowski, Robert M Russell, and Michael A Grusak. *The American Journal of Clinical Nutrition.*

66 Material for the Press Conference of the State Council Information Office. The Nutrition and Health Status of the Chinese People. October 12, 2004. http://goldenrice.org/PDFs/China_nutr_rep_2004_en.pdf

school in the Hunan province of China in healthy schoolchildren (with normal biochemical test results) aged 6–8 y either initially free of parasitic infection or verified free of infection after treatment with 400 mg albendazole (GlaxoSmithKline)."[67] The study, published in 2012, found that Golden Rice is more effective than spinach at providing Vitamin A to children. "The β-carotene in GR is as effective as pure β-carotene in oil and better than that in spinach at providing vitamin A to children. A bowl of ~100 to 150 g cooked GR (50 g dry weight) can provide ~60% of the Chinese Recommended Nutrient Intake of vitamin A for 6–8-year-old children."[68]

While Golden Rice would not be efficient as a stand-alone strategy, its use could have significant benefit. "Zimmermann and Qaim (2004) and Stein et al. (2007) express the social burden of nutrient deficiency in terms of disability-adjusted life years (DALYs) lost. Zimmermann and Qaim (2004) investigate vitamin A–enriched Golden Rice in the Philippines, using the data on food intake collected by the Food and Nutrition Research Institute (1993, 1998) and postulating a function that relates vitamin A intake to disease levels. (They note that while a general relationship is widely accepted in the literature, concrete evidence on the exact numerical association is lacking.) They estimate that Golden Rice could generate social benefits of US$16–88 million per year through reducing the incidence of blindness and premature death. Combining these data with a cost-benefit analysis of investments in research and development, they find high internal rates of return."[69]

67-68 β-Carotene in Golden Rice is as good as β-carotene in oil at providing vitamin A to children. Guangwen Tang, Yuming Hu, Shi-an Yin, Yin Wang, Gerard E Dallal, Michael A Grusak, and Robert M Russell. *The American Journal of Clinical Nutrition.*

69 Measuring the Economic Impacts of Transgenic Crops in Developing Agriculture during the First Decade: Approaches, Findings, and Future Directions, IFPRI Food Policy Review 10. Chapter 4: Impacts on Consumers, Impact on Nutrition.

Myths and Facts about Agricultural Biotechnology

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