GMO FAQ: Do GMO Bt (insect-resistant) crops pose a threat to human health or the environment?

Bt is a bacterium found organically in the soil. It is extremely effective in repelling or killing target insects but is harmless to beneficial insects, reptiles, birds and mammals, including humans, which cannot digest the active Bt proteins.

Bt was first used by farmers in France in 1920 and gradually adopted by organic and some conventional growers. In the US, Bt was first used commercially in 1958; by 1961 it was registered as a pesticide by the Environmental Protection Agency (EPA). Following World War II, scientists began developing powerful synthetic pesticides that were widely used into the early 1960s. Some insects evolved resistance to these chemicals, sparking research by industry and government that led to the engineering of plants that could naturally express *Bt* proteins. Scientists were able to transfer the genes that encode the crystal, or Cry, proteins that are toxic to insects into the genomes of certain crops. When hungry insects try to eat the plants, the pests consume the toxin and die in a matter of days.

Bt corn was the first of these crop varieties, introduced in 1996. Scientists have since isolated thousands of *Bt* strains, many of them incorporated into different varieties of GMO crops, including corn, brinjal (eggplant), potato and cotton. Today, *Bt* varieties comprise more than 80 percent of the cotton and corn (used mostly for animal feed, although also some sweet corn) grown in the US. *Bt* potatoes are no longer grown due to a lack of demand from farmers. At the end of 2017, an estimated 23.3 million hectares of land were planted with crops containing Bt genes. The following table shows the countries that have commercialized Bt crops (with single and stacked genes) and their products, from 1996 to 2017.

Bt crop	Country
Cotton	Argentina, Australia, Brazil, Burkina Faso, Canada, China, Colombia, Costa Rica, Ethiopia, European Union, India, Japan, Malaysia, Mexico, Myanmar, New Zealand, Nigeria, Pakistan, Paraguay, Philippines, Singapore, South Africa, South Korea, Sudan, Swaziland, Taiwan,USA
Eggplant	Bangladesh
Maize	Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Egypt, EU, Honduras, Indonesia, Japan, Malaysia, Mexico, New Zealand, Pakistan, Panama, Paraguay, Philippines, Russian Federation, Singapore, South Africa, South Korea, Switzerland, Taiwan, Thailand, Turkey, USA, Uruguay, Vietnam, Zambia
Poplar	China
Potato	Australia, Canada, Japan, Mexico, New Zealand, Philippines, Russian Federation, South Korea, USA
Rice	China, Iran, USA
Soybean	Argentina, Australia, Brazil, Canada, China, Colombia, EU, India, Indonesia, Japan, Malaysia, Mexico, New Zealand, Paraguay, Philippines, Russian Federation, Singapore, South Africa, South Korea, Taiwan, Thailand, Turkey, USA, Uruguay, Vietnam
Sugarcane	Brazil, Canada, USA
Tomato	Canada, USA

Image credit: ISAAA GM Approval Database

Overall insecticide use in the US has plummeted since the mid-1990s, largely because of Bt commodity crops. A meta-analysis published in the journal PLoS One looked at the environmental impact of *Bt* cotton in the US between 1995-2015. The authors found that the insect-resistant crops cut pesticide use and crop losses associated with common pests like the bollworm, corn earworm and tobacco budworm between 47 and 81 percent, depending on which region of the country they examined.

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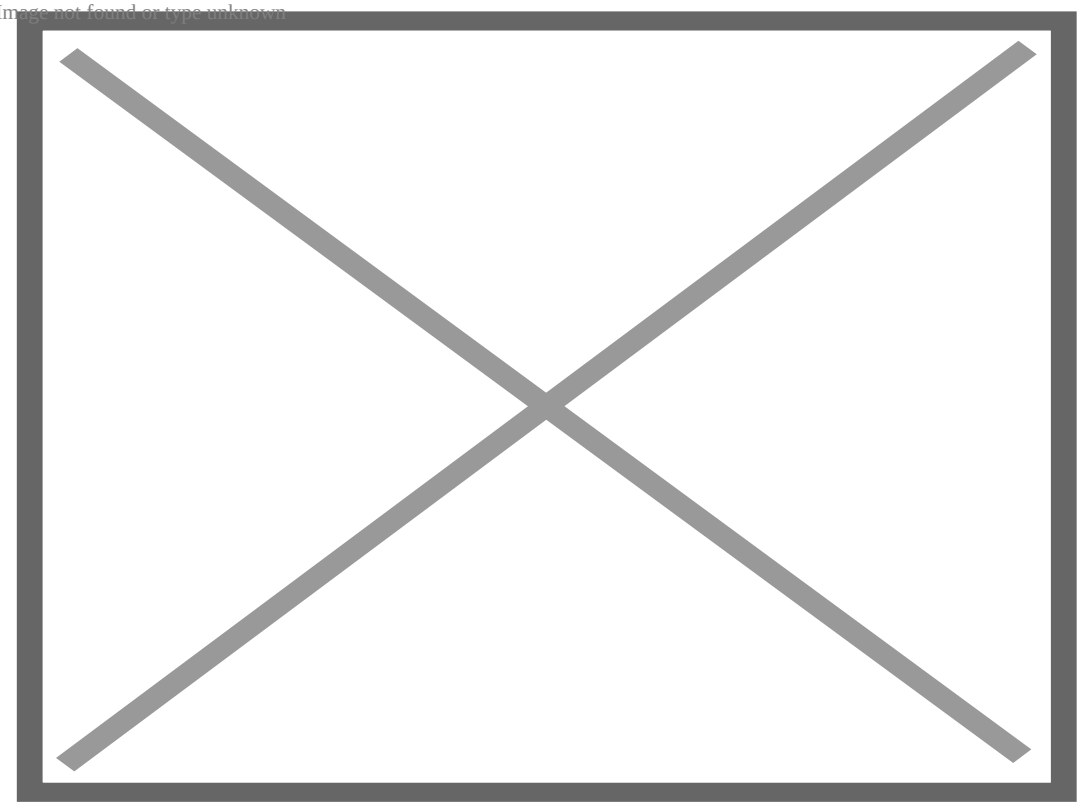
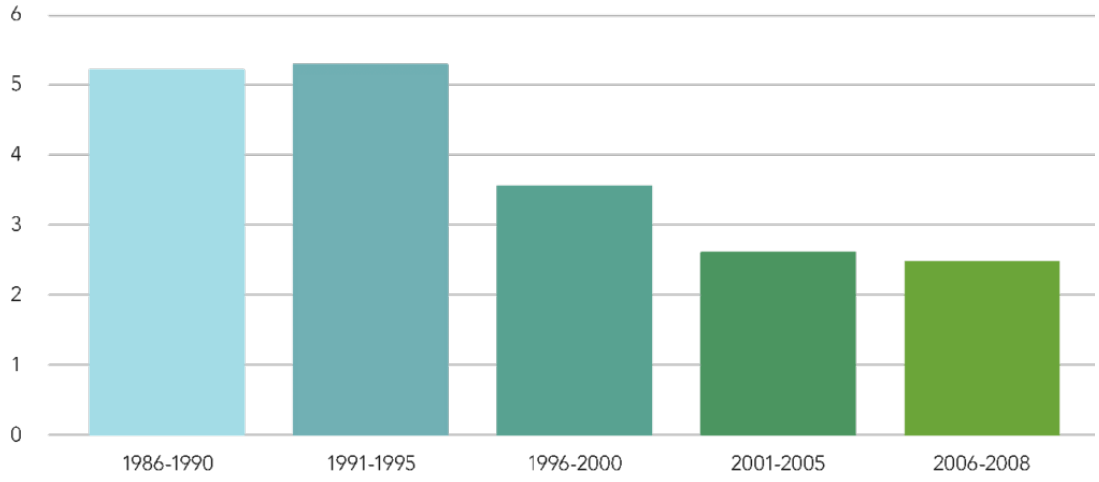


Average Number of Insecticide Applications Made to U.S. Cotton, 1986-2008

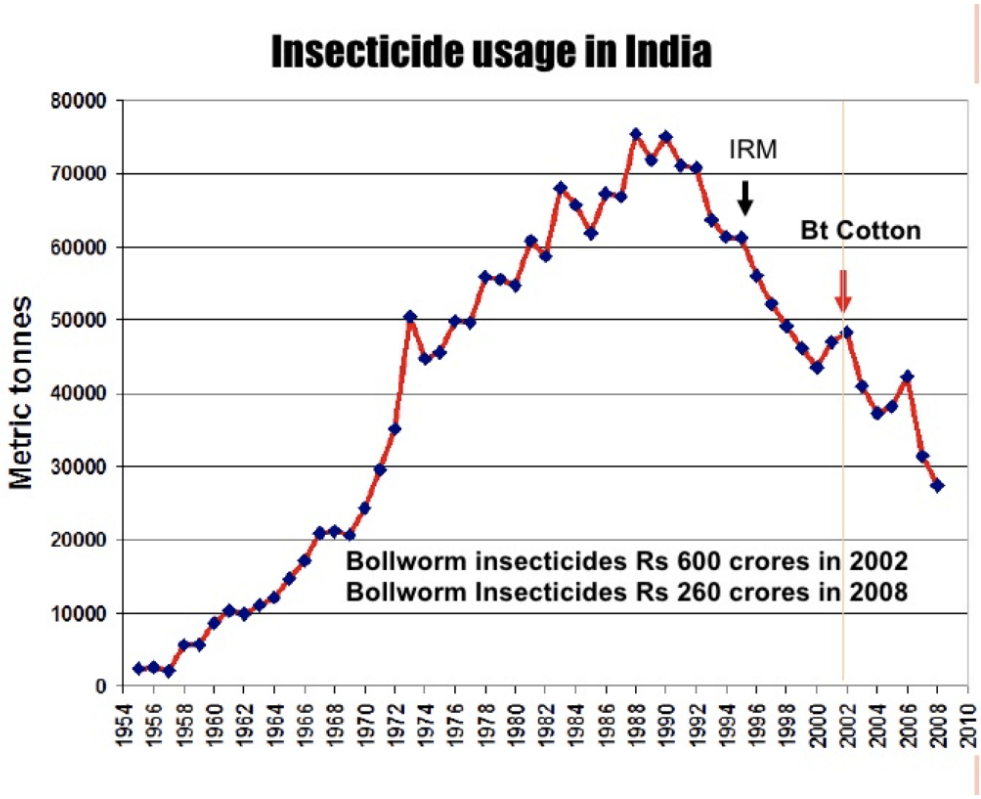


More than 17 percent of the brinjal in Bangladesh grown since 2014 is *Bt* engineered to kill eggplant fruit and shoot borer (BFSB). Historically, virtually all brinjal farmers in Bangladesh relied solely on insecticide sprays to control BFSB, with farmers applying as many as 84 insecticide sprays during the growing season, now reduced to 1 or 2 applications, leading to a sharp drop in pesticide-related illnesses. A 2018 study found farmers saved 61 percent of pesticide costs compared to non-*Bt* brinjal farmers, experienced no losses due to insect attacks (versus non-*Bt* farmers who experienced 36-45 percent infestation) and earned higher net returns.

Bt cotton was commercially introduced in India in 2002 (but years earlier on the black market), and now makes up 95 percent of the market. The genetically engineered crop increased yields 30-60 percent and household income by 18 percent. The *Bt* boom transformed the country from a net importer of cotton to the world's third largest exporter behind only China and the United States.

Some scholars critical of genetic engineering have argued that India's experience with Bt cotton has been oversold, and suggest that yield increases have had more to do with changes in fertilizer use and other factors unrelated to insect-resistant crops. Responding to this criticism in October 2020, agricultural economist Matin Qaim agreed that many other factors can affect yields. Yet after reviewing the relevant data, Qaim concluded:

"Results showed that—after controlling for all other factors—Bt adoption had increased cotton yields by 24%, farmers' profits by 50% and farm household living standards by 18% …. The same data also revealed that chemical insecticide quantities declined by more than 40% through Bt adoption, with the largest reductions in the most toxic active ingredients previously sprayed to control the American bollworm."



The incredibly quick adoption of *Bt* cotton seeds by Indian farmers accelerated a reduction in insecticide use already underway in Indian cotton fields. A study pegged the drop at an estimated 60 percent, avoiding at least 2.4 million cases of pesticide poisonings each year. As a corollary benefit, *Bt* seeds also reduced pesticide applications by non-*Bt* farmers because of the halo effect of an overall smaller pest population.

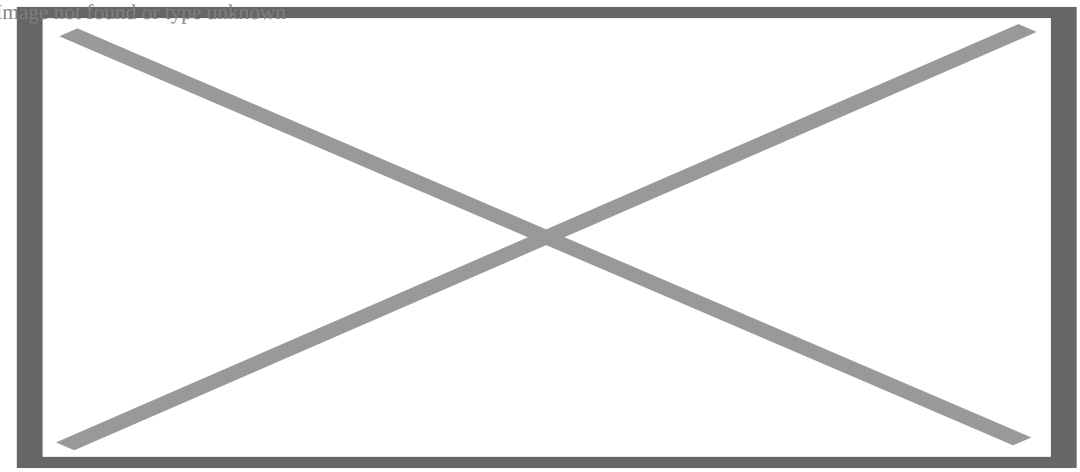
An organic industry trade group called the Organic Consumers Association argues that Bt crops are "lethal" to beneficial insects including ladybugs, butterflies and honeybees. There is no evidence to support that claim. A 2003 article authored by EPA researchers and published in Nature Biotechnology found that Bt corn, cotton and potato varieties do not pose a threat to beneficial insects, including honeybees, ladybugs and butterflies.

A 2016 review article examined 76 studies published over the preceding 20 years that investigated the impact of Bt crops on beneficial insects, natural pest controllers, bacteria, growth-promoting microbes, pollinators, soil dwellers, aquatic and terrestrial vertebrates and mammals. The authors wrote that no "….significant harmful impact has been reported in any case study related to approved [Bt crops]."

Anti-GMO osteopath and natural products salesman Joseph Mercola has maintained that *Bt* crops are fueling the development of "super-pests" resistant to the toxic Cry proteins produced by the plants, which in turn is driving up insecticide use.

“It’s clear that *Bt* plants have led to decreases in spraying,” Marcia Ishii-Eiteman, senior scientist at the Pesticide Action Network, told Grist’s Nathanael Johnson. “But,” she added, “as was predicted 10 years ago, we are starting to see the insect resistance to *Bt*.”

There is some truth to this claim, as both organic farmers using Bt sprays and conventional farmers using Bt seeds have experienced the evolution of some insects resistant to the natural insecticide. There has been one notable problem. In Puerto Rico insects became nearly impervious to *Bt* corn in just three years.



Spodoptera frugiperda gained resistance to genetically engineered corn in Puerto Rico in just three years.

However, the insect-resistant crops have been a blessing to the environment, claimed University of Arizona entomologist Bruce Tabashnik. The European corn borer remains completely susceptible to *Bt*, a boon for corn farmers in the US Midwest. Insecticide use has continued its sharp downward trend in the US. And the use of organophosphates (a far more toxic and hazardous class of insecticide) fell 55 percent between 1997 and 2007, in large part because of the use of insect-resistant transgenics. In January 2021, Tabashnik and colleagues reported that Bt cotton (along with sterile pink bollworm moths) helped rid the cotton-growing areas of the continental United States and northern Mexico of the pest, which cotton growers in both countries had battled for a century:

“The removal of this pest saved farmers in the United States $192 million from 2014 to 2019. It also eliminated the environmental and safety hazards associated with insecticide sprays that had previously targeted the pink bollworm and facilitated an 82% reduction in insecticides used against all cotton pests in Arizona.”

Anti-GMO activists have also argued for many years that *Bt* crops pose a serious threat to human health. Jeffery Smith, an anti-GMO activist who heads the one-man Institute for Responsible Technology has alleged without evidence that *Bt* crops may cause sterility and cancer. The activist website GM Watch has argued they can potentially damage vital organs such as the liver and kidneys.

Citing a small Canadian study from 2011, Dr. Mercola said in 2013:

These shocking results also raise the frightening possibility that eating Bt corn might actually turn your intestinal flora into a sort of "living pesticide factory" essentially manufacturing Bt toxin from within your digestive system on a continuing basis through the transference of the Bt-producing gene to your gut bacteria.

Mercola said consumption of *Bt* crops may lead to "gastrointestinal problems autoimmune diseases [and] childhood learning disorders" and that rats fed a variety of Monsanto's *Bt* corn experienced an immune response indicative of "….various disease states including cancer. There were also signs of liver and kidney toxicity."

Many activists have argued that *Bt* crops can produce dangerous allergens. In 2018, GM Watch said that a "study performed in mice found that the GM *Bt* toxin Cry1Ac is immunogenic, allergenic, and able to induce anaphylaxis (a severe allergic response that can result in suffocation)."

Following the publication of that study, in November 2018, the European Food Safety Authority (EFSA) re-evaluated the allergenicity of the Cry1Ac protein at the request of the European Commission. The EFSA wrote that it stood by its seven previous evaluations published between 2010 and 2018, noting that "….other risk assessment bodies conclude that there are currently no indications of safety concern regarding Cry proteins in the context of the GM plants assessed." In a follow-up study of Bt corn published in October 2020, the EFSA again concluded that the evidence "does not indicate any adverse effects on human and animal health or the environment arising from the cultivation of [Bt] maize …. Consequently, previous evaluations on the safety of maize MON 810 …. remain valid."

The US Environmental Protection Agency has addressed these health concerns numerous times, beginning in 2001 when it issued a 50-page report evaluating the potential health risks, including allergenicity, posed by four Cry proteins commonly inserted into Bt corn and potato. It concluded: "None of the products registered at this time, all of which have tolerance exemptions for food use, show any characteristics of toxins or food allergens."

The EPA noted additionally that consumers may be exposed to Bt toxins at very low levels through processed foods and drinking water, but "….a lack of mammalian toxicity and the digestibility of the plant-incorporated protectants has been demonstrated."

Research has continued to affirm the relative safety of Bt crops. A January 2021 animal feeding study published by Nature, for example, found that Bt rice was unlikely to pose a greater health risk than its conventional counterpart. The study authors concluded that "GM Bt rice caused no obvious adverse effects on rats as evaluated by several biological parameters, including organ weight, serum chemistry, hematology, thyroidal and sexual hormones level, urinalysis, and histopathology."