Organic v conventional using GMOs: Which is the more sustainable farming?

Many consumers spend more for organic food to avoid genetically modified products in part because they believe that “industrial agriculture” endangers the environment and produces less nutritious food. Many agroecology supporters also argue that a global move towards sustainable, organic agriculture is necessary to save the planet from the misuse of harmful chemicals and protect fragile soil ecosystems. Currently about 1 percent of the world food supply is grown using the kind of organic principles embraced in the United States and Europe.

When assessing sustainability, one should consider what organic farming is and is not. The official definition of what is organic, established by the US Department of Agriculture’s National Organic Standards Board (NOSB) in 1995, captured this naturalistic perspective:

> *Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain, or enhance ecological harmony. The primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people.*

The USDA additionally states that crop products that receive a certified organic label must be free from genetic modification; grown without conventional fertilizers and pesticides; and processed without food additives or ionizing radiation. In addition, animals must be raised without the use of artificial hormones and antibiotics.

When establishing the organic standards, both the USDA and the industry stressed that the organic seal should not convey food safety, quality or nutrition information. Secretary of Agriculture Dan Glickman stated, “Let me be clear about one thing. The organic label is a marketing tool. It is not a statement about food safety. Nor is ‘organic’ a value judgment about nutrition or quality.” Nonetheless, many customers willing to spend more for the seal or a non GMO label do so because they believe that their food will be “safer,” “healthier” or more “environmentally friendly”—despite an absence of evidence to support that belief.

The guiding principal of organic—relying on ‘natural’ inputs—was forged early in the 20th century before toxicology, environmental studies and climate science emerged. Although there is much wisdom in organic farming, some methods are dated and contradict what we know about modern ecological practices.

The issue of sustainability is complex and confounding. For example, the growing demand for organic and non-GMO products in the U.S. has prompted some manufacturers to switch to less sustainable sources. Chipotle abandoned the use of GMO soy oil, switching to what it claimed was ‘more sustainable’ sunflower because, it stated, soy products have been linked to the growth of herbicide-resistant so-called superweeds which have proliferated with the increased usage of glyphosate. Chipotle does not tell its customers that the sunflower oil that replaced the soy oil is derived from seeds developed using conventional breeding techniques to resist an herbicide called an ALS inhibitor. It's actually more resistant to herbicides than GMO soy–so Chipotle's decision to replace soy oil with sunflower oil results in the use of more chemical inputs, not less.

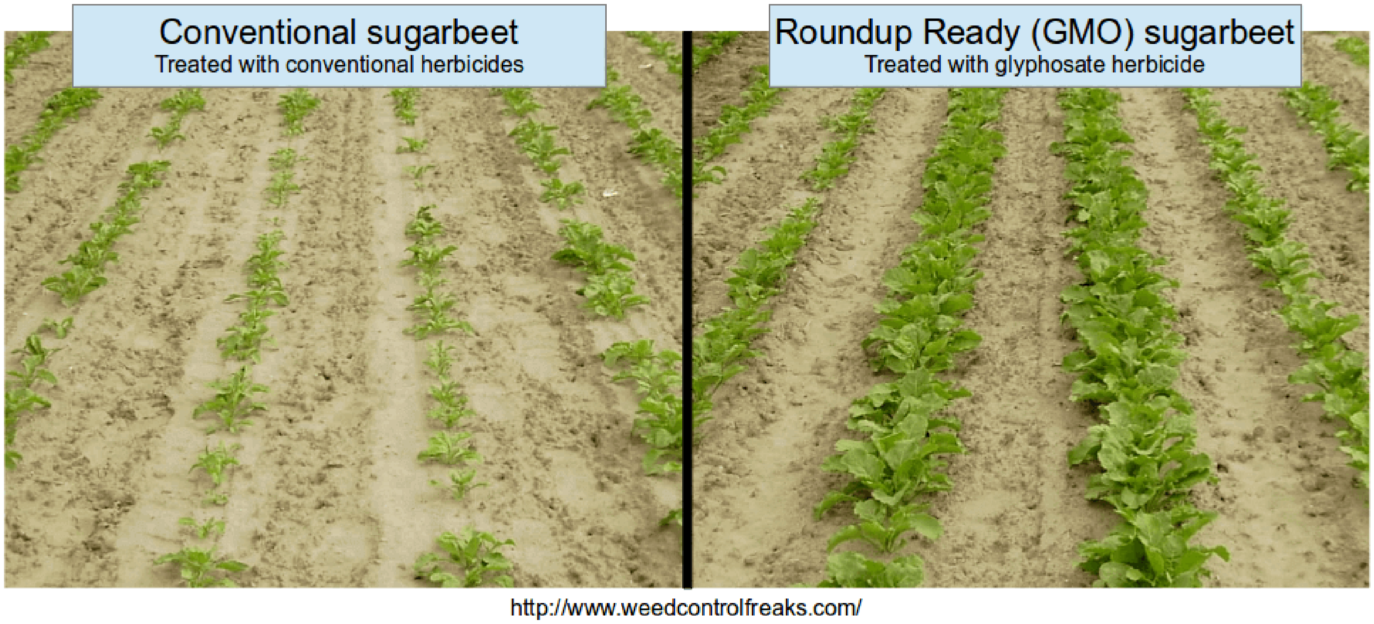
Pressured by anti-GMO groups such as GMOInside and wary consumers, many small firms and some large food companies–Hershey is the most prominent–are switching from so-called GMO sugar (sucrose made from herbicide tolerant sugar beets) to sucrose made from non-GMO sugar cane. Sucrose contains no DNA so there is no detectable difference between sugar from GMO or non-GMO sources.

GMO critics say non-GMO sugar is more sustainable, but scientists challenge that claim. Most non GMO sugar is imported, resulting in wasteful and carbon-creating transportation costs. And as NPR has reported, "Planting genetically modified sugar beets allows them to kill their weeds with fewer chemicals." GM sugar beets are sprayed a few times during the growing season while non-GMO varieties "spray their crop every 10 days or so with a 'witches brew' of five or six different weedkillers." Environmentalists have long campaigned against sugar cane plantation farming, particularly the burning of the cane, which removes the majority of leaves, leaving the sugar-laden canes behind for harvest. Despite the clear environmental benefits of sugar made from GMO sugar beets, GMO Inside, a division of Green America, celebrated Hershey's decision to remove it from their products, calling it a "victory for consumers."

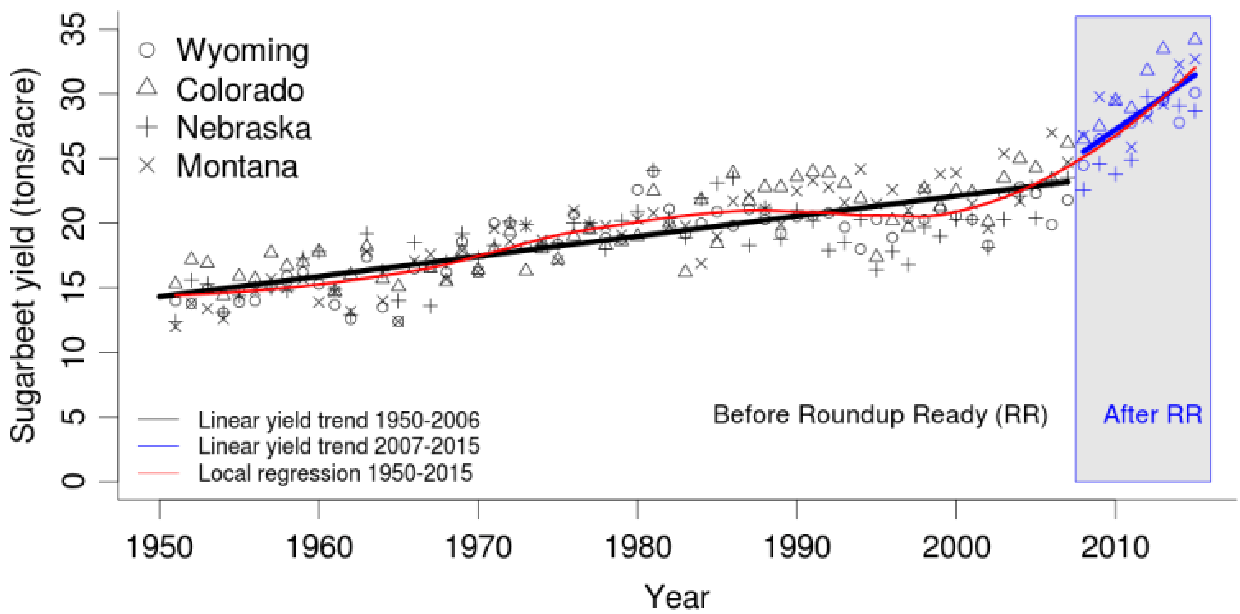
"Even after this much herbicide spraying, writes weed scientist Andrew Kniss, "around 40 to 60% of sugarbeet fields had to be hand-weeded because the herbicides rarely provided complete weed control. Compare that to the Roundup Ready (GMO) system, where 2 or 3 applications of glyphosate have replaced the many herbicide sprays that were used previously, while providing better weed control."

> The improved weed control provided by Roundup Ready varieties led to rapid environmental gains. By 2009, only two years after widespread adoption of GMO sugarbeet, over 50,000 acres of land was converted to some form of reduced or conservation tillage practices in Nebraska, Colorado, and Wyoming. That number is probably much higher now. Conservation tillage practices improve soil health, reduce soil erosion, and preserve soil moisture. Conservation tillage simply wasn't possible in sugarbeet before the introduction of Roundup Ready varieties, because intensive tillage was needed to obtain adequate weed control in the crop.

Using glyphosate rather than a mix of more toxic chemicals, more frequently applied, has resulted in both a reduction in chemical usage and a sharp increase in yield.



Photos show two different fields on the same day during a 2002 weed study in Nebraska.



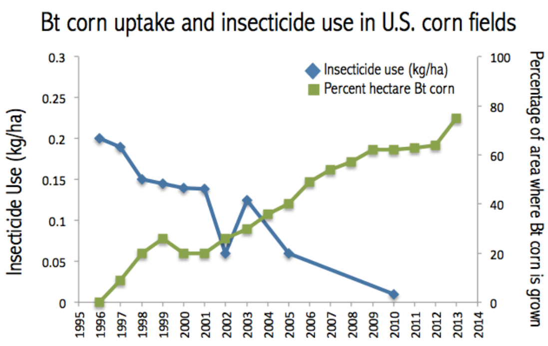
Sugar beet yields increased substantially after the introduction of Round-up Ready sugar beets. [Source here](#).

The demand in the U.S. for organic feed for cows to serve customers who want to buy milk, eggs and meat sourced from cattle not fed GMO grain has also caused another sustainability problem. Eggs and meat sold at Whole Foods and other organic marketers are [now being imported](#) from Romania, Ukraine and India where ecological standards are much lower than in the U.S. Transportation import costs add to the greenhouse gas problem.

The key issue for scientists and farmers: How do we measure agricultural sustainability? Here are the three major areas that experts examine:

Herbicides and Insecticides

Claims by organic supporters that conventional agriculture and the use of GMOs in particular has caused a dramatic increase in chemical usage is commonplace, often repeated in media accounts. Those claims are based almost entirely on the research of Charles Benbrook, an organic industry consultant. Benbrook claimed in 2012 that the use of GMO crops has "backfired" and results in unsustainable increased use of pesticides (both insecticide and herbicide) of 7%, almost of it due to the increase in glyphosate tied to herbicide resistant GMO crops. Graham Brookes of PG Economics published a peer reviewed report earlier that year using the same data that reached a different conclusion: GM crops may actually have reduced worldwide pesticide use by 9.1%.



Adapted from Malakof D. and Stokstad E. Pesticide Planet. Science Magazine. 16 August 2013.

University of Wyoming weed scientist Andrew Kniss examined these conflicting studies, questioning: "How could …. one person …. conclude that herbicide use increased by 239 million kg, while another person concludes that herbicide use was reduced by 225 million kg?"

Both studies agreed on the total amount of herbicide applied to GMO crops between 1997-2011, according to Kniss. However, Benbrook concluded that herbicide use would have declined over this 14-year period had GMO crops never been introduced. Brookes, on the other hand, argued that use of these chemicals would have increased had herbicide-tolerant crops never been developed. Benbrook calculated his estimate by comparing total herbicide applied to GMO crops to total herbicide applied to conventional crops between 1997-2011. But Kniss argued that this methodology may have been inappropriate:

> I'm not convinced Benbrook's methods accurately approximate what soybean growers (or cotton or corn growers) would be doing if GE technology never existed …. it is not reasonable to assume that the 10% of growers who did not adopt GE crops are representative of what the other 90% would be doing if [GMO] technology never existed.

In contrast to Benbrook, Brookes arrived at his very different estimate by assuming that all the farmers who adopted GMO crops in 1990s would have ended up using greater quantities of herbicides besides glyphosate had Roundup Ready crops never been introduced. Both researchers, then, reached their conclusions by extrapolating from incomplete data. Where does that leave us? Kniss:

> I don't think it is possible to say for sure what the impact of [GMO] crops has been. My personal opinion – based on the data I've analyzed – is that we've probably seen a net benefit [eg, reduction] with respect to both toxicity and the evolution of 'superweeds.' And one could even make an argument that adoption of GE crops has slowed the increase in herbicide use.

Other recent studies support Kniss' conclusion. A meta-study crunching global data from 147 other studies published in 2014 in PLOS ONE concluded that "GM technology adoption has reduced chemical pesticide use by 37%."

The US government has reviewed data for the United States. According to a USDA report of GMO adoption over its first 15 years, based on research from National Research Council, "GE crops lead to reduced pesticide use and/or to use of pesticides with lower toxicity compared to those used on conventional crops." The use of herbicides "declined slightly in the first years following the introduction of Ht [herbicide tolerant] seeds in 1996, but increased modestly in later years," the USDA reports, adding:

> *Despite the relatively minor effect HT crop adoption has had on overall herbicide usage, HT crop adoption has enabled farmers to substitute glyphosate (which many HT crops are designed to tolerate) for more traditional herbicides. Because glyphosate is significantly less toxic and less persistent than traditional herbicides, the net impact of HT crop adoption is an improvement in environmental quality and a reduction in health risks.* Conventional farmers use synthetic chemicals and are more likely to use mono-cropping, which can reduce biological diversity. In conventional systems, farmers apply pesticides and herbicides to crops at a more efficient rate if they are made up of just one type of plant, but this practice has unintended consequences. Because the goal of conventional agriculture is to maximize yields, environmental health can be challenged if farmers are not sustainably minded.

The USDA statistics also show a 10-fold decrease in insecticide use since the introduction of Bt (insect resistant) corn and cotton. By 2010, only 9 percent of all US. corn farmers used insecticides, and the number has dropped to below 5% since then. "This is consistent with the steady decline in European corn borer populations over the last decade that has been shown to be a direct result of Bt adoption," the government reported. Even small reductions in insecticides leads to big increases in beneficial insects, increasing ecological diversity.

Biodiversity

According to an article in the *Journal of Applied Ecology*, "…farmland biodiversity is typically negatively related to crop yield; generally, organic farming *per se* does not have an effect other than via reducing yields and therefore increasing biodiversity.

Organic advocates cite numerous studies that suggest the environmental and economic impact of organic farming is less than conventional farming. In a study comparing 14 organic arable fields with 15 conventional ones in New Zealand, the total economic value of biological pest control, soil formation and the mineralization of plant nutrients in the organic fields was significantly greater. That said, organic farming is less efficient in certain soil conditions, such as high-alkaline or high-acidity environments.

While conventional farmers have an array of synthetic pesticides at their disposal, organic famers rely more on weeding, predatory insects and tillage. But that does not mean they are chemical free, as anti-GMO publications often imply. A list of approved chemicals and other substances can be found here.

In 2015, *Consumer Reports* released, "From Crop to Table Report," with a section misleadingly headlined, "Organic: Farming Without Pesticides." Organic farmers, like their conventional counterparts, use chemicals, usually natural natural fungicides and pesticides—more than 20 are approved—to prevent critters from destroying crops.

As is the case with some synthetic chemicals, natural pesticides and insecticides like rotenone-pyrethrin, borax, borates, pyrethrums, lime sulfur or Spinosad, are toxic and may be potentially harmful to humans, insects and fish. Scientist Christie Wilcox, writing for *Scientific American*, had this to say about the perceived safety benefits of natural chemicals:

> *Not only are organic pesticides not safe, they might actually be worse than the ones used by the conventional agriculture industry. Canadian scientists pitted 'reduced-risk' organic and synthetic pesticides against each other in controlling a problematic pest, the soybean aphid. They found that not only were the synthetic pesticides more effective means of control, the organic pesticides were more ecologically damaging, including causing higher mortality in other, non-target species like the aphid's predators….* Some natural chemicals don't work as well, requiring larger quantities, another sustainability problem.

Plant pathologist Steve Savage similarly has noted:

> *[C]opper-based fungicides are among the few options available to an organic grower for the control of fungal plant diseases. These are high-use rate products that require frequent re-application and which are quite toxic to aquatic invertebrates. There are much more effective, and far less toxic, synthetic fungicide options without environmental issues, and which, unlike copper, break down into completely innocuous materials. Organic growers can't use those fungicides. Similarly, there are many environmentally benign, synthetic insecticides and herbicides which cannot be used.*

It's important to underscore that most organic practices and chemicals are both effective and safe. As to differences between the two categories, "You can't generalize that broadly," said Rob Wallbridge, a retired organic farmer in Quebec, Canada. "Every pesticide has a different profile, and there are many different ways to define safety." Wallbridge added that the Canadian study Wilcox cited was a laboratory experiment that didn't actually evaluate real-world organic pest control practices.

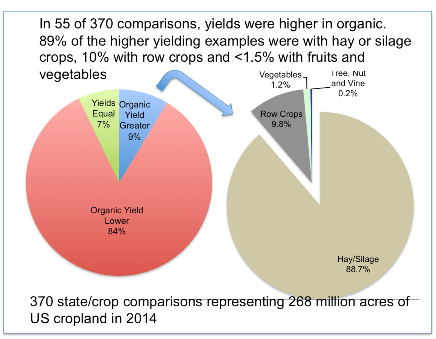
It's also important to note that conventional farmers are allowed to use organic-approved pesticides, and they often do so. For example, the most popular organic insecticide, Spinosad, is widely used by conventional farmers as well, according to data from the California Pesticide Information Portal, compiled by Savage. Dow Chemical sells the organic version as Entrust and the conventional version, which contains different adjuvants, as Success. Spinetoram, a synthetic derivative, is sold as Radiant.

The fact of the matter is that all pesticides, whether used in organic or conventional agriculture are subject to the same regulations, enforced by the federal Environmental Protection Agency (EPA), state and local governments. And while it’s true that some pesticides used in organic farming are more toxic than their synthetic counterparts, most pesticides in use today are classified by the EPA as Category IV “essentially non-toxic,” Savage has pointed out.

Population growth and growing affluence in the developing world will require a sharp increase in necessary food calories, which can only occur by expanding farmable acreage. Relying on lower-yield organic agriculture, while offering mixed sustainability benefits, could threaten the world’s remaining forests.

There is, however, some loss of biodiversity related to the large-scale modern farming needed to feed the world’s growing population. But it is not specific to the use of genetic engineering. Rather, it’s the natural result of using chemicals and other farming methods aimed at controlling weeds that can sap yields, according to Peter Raven, a botanist and former president of Missouri Botanical Garden. Raven wrote in the journal New Biotechnology:

> *In short, the application of GE technology to the improvement of crops does not, in itself, limit the overall diversity of the crops, whereas the development of modern agriculture, in which certain genetically defined strains are grown over wide areas and other strains that were cultivated locally earlier may disappear, does. The preservation of genetic diversity in crops is important and of general interest, but the appearance of GE crops did not cause the problem or advance its spread.*



Source: Forbes.coma

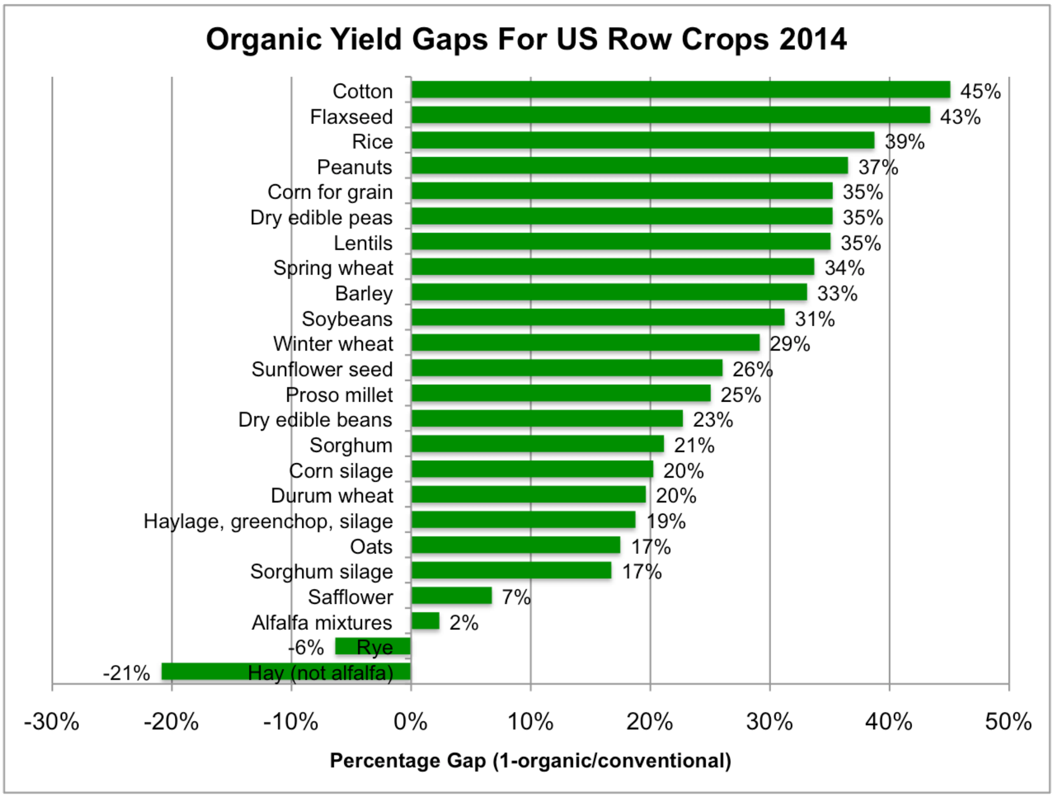
Yield gaps and land usage

Per-acre yields of organic crops are significantly lower than those for conventional. In 2012, a team of Canadian and US researchers published a report in Nature, detailing their meta analysis of crop data for conventional versus organic farming. Among their conclusions:

> Our analysis of available data shows that, overall, organic yields are typically lower than conventional yields. But

> these yield differences are highly contextual, depending on system and site characteristics, and range from 5% lower organic yields (rain-fed legumes and perennials on weak-acidic to weak-alkaline soils), 13% lower yields (when best organic practices are used), to 34% lower yields (when the conventional and organic systems are most comparable).

In a representative sample in the US, from 2014, scientist Steve Savage examined USDA data and found organic corn faced a 35% shortfall; soybeans 31%; and cotton 45%. It also costs more per acre to produce organic crops, which have substantially higher fuel, labor and capital costs.



Source: Forbes.com

Recent meta-studies show ranges show a 29-44% shortfall, with even higher differences among some grains and vegetables. These gaps have been established both by meta-analyses of published research and by USDA surveys.

> Technology innovation is key to preserving and increasing biodiversity, and here organic farming often falls short. Biotech crops, including those with glyphosate-tolerant technology, have improved productivity, which is taking pressure off the need to bring new land into agriculture to feed the world's expanding population. As biodiversity is best preserved in non-agricultural land, protecting exiting natural habitats is crucial. The world is close to exploiting max arable land for farming. Increases in production can only come by growing more food on less land. The only way to do this is through using more productivity enhancing technologies on the land remaining in agriculture. That would entail embracing yield-enhancing technologies such as gene editing, and continuing to use proven and effective low-impact existing technologies like glyphosate that are better for the environment from an eco-toxicity

perspective than effective alternatives.

It is also important to note that biodiversity depends more on reducing the encroachment of farming on natural habitats, an especially challenging issue going forward as global food demand soars. The organic yield lag cannot be significantly reduced. Biotech crops, including glyphosate tolerant technology have improved farming productivity, taking pressure off the need to bring new land into agriculture to feed the world's expanding population.

Non-farmed land is the best way to preserve biodiversity. That means we have to protect what natural land/habitat we have and take some agricultural land out of production. The only way to do this is through more use of productivity-enhancing technology on the land remaining in agriculture — which means relying on new technologies, from artificial intelligence to biotechnology, including gene editing, and without abandoning effective existing technologies like glyphosate that is more effective and better for the environment from an eco-toxicity perspective than many alternatives.

Conservation tillage and greenhouse gasses

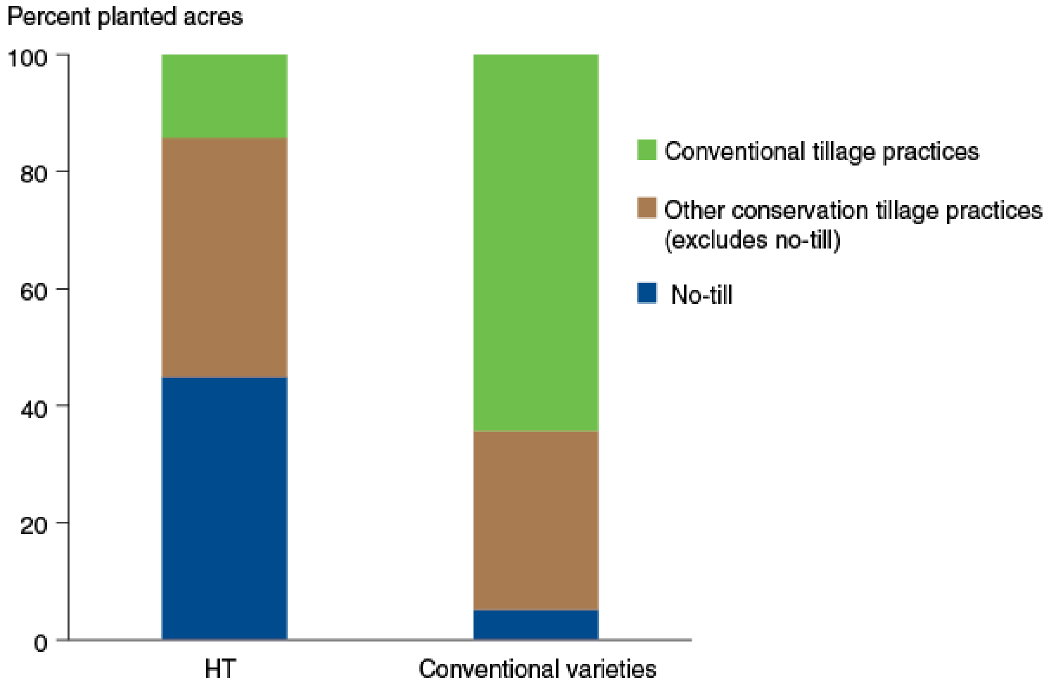
Growing concerns about climate change—and estimates that one third of greenhouse gas emissions come from agriculture—have helped fuel the market for organic foods, which is perceived as reducing environmental impacts. Media outlets, such as the Wall Street Journal, have encouraged the idea that manure composting, cover crops and crop rotation, which put carbon into the soil, could help alleviate global warming: “Organic practices could counteract the world's yearly carbon dioxide output while producing the same amount of food as conventional farming.”

Many scientists contest those claims. One of the great early advances of organic farming was the use of compost to promote soil health. But there are sustainability trade-offs. During the process of composting methane is emitted, a greenhouse gas 30 times more potent than carbon dioxide. Methane is also released in catastrophic amounts by flatulent cows, the primary generator of organic waste for use as fertilizer. Cattle livestock is already blamed for generating nearly 20% more greenhouse gases in terms of carbon equivalency as compared to driving automobiles.

The use of organic fertilizer often results in the release of nitrous oxide, a highly potent greenhouse gas. Organic farmers also rely on tillage far more than their conventional counterparts. Many conventional farmers have switched to no-till, ridge-till, and mulch oil (reduced plowing up of the soil) practices, facilitated by the use of GMO crops, because tillage contributes to soil erosion and the release of greenhouse gasses. According to a 2014 USDA analysis:

Conservation tillage (including no-till, ridge-till, and mulch-till) is known to provide environmental benefits and is facilitated by use of HT crops. … By 2006, approximately 86 percent of HT soybean planted acres were under conservation tillage, compared to only 36 percent of conventional soybean acres. Differences in the use of no-till were just as pronounced. While approximately 45 percent of HT soybean acres were cultivated using no-till technologies in 2006, only 5 percent of the acres planted with conventional seeds were cultivated using no-till techniques, which are often considered the most effective of all conservation tillage systems.

Adopters of HT soybeans had higher rates of adoption of conservation tillage relative to users of conventional varieties, 2006



Conservation tillage includes no-till, ridge-till and mulch-till.
Source: USDA Economic Research Service using data from 2006 ARMS Phase II soybean survey.

There is an emerging science consensus that GMO crops and conventional agriculture in general are more sustainable when carbon emissions are factored into the equation. A 2016 study by Purdue University researchers found that agricultural greenhouse gas emissions would increase by nearly 14 percent if there were a ban on GMOs.

> As GMO find wider and wider usage, there is a corresponding growth in the popular hysteria surrounding the technology. Environmental activists push for GMO bans, without adequately considering the impacts such bans might have. The losses associated with a global ban would be twofold: the losses actually realized and the potential losses when compared to an alternative adoption schema.

These findings were supported by a December 2018 study in Nature, which found that organic farming produces far more heat-trapping greenhouse gases than conventional agricultural. This is because organic growers must farm more land to produce the same amount of food that a conventional farmer produces. The researchers developed a new metric called Carbon Opportunity Cost to estimate the effect of greater land use on climate change. They found that organic production has as much as a 70 percent greater impact. Stefan Wirsenius, a researcher at Chalmers University of Technology in Sweden and one of the study's authors:

> The fact that more land use leads to greater climate impact has not often been taken into account in earlier comparisons between organic and conventional food …. This is a big oversight, because, as our study shows, this effect can be many times bigger than the greenhouse gas effects, which are normally included.

The research was criticized by organic food proponents at the Rodale Institute because it was based on yields of just two crops. However, an October 2019 study conducted by scientists at the Royal Agricultural University in the UK seemed to validate the Swedish results. The researchers concluded that if all farms in England and Wales converted to organic production, yields would decline by half, necessitating the use of more farmland elsewhere in the world to make up the deficit. According to co-author Laurence Smith, himself an advocate of organic agriculture, "[t]he key message from my perspective is that you can't really have your cake and eat it …."