The debate over the environmental impact of genetically modified (GM) crops is growing increasingly complex, intense, and extremely emotional. It is further complicated as new research is published. Are GM crops safe for the environment?

Assessing the environmental impact of GM crops is often difficult as many factors are considered. Some scientists focus on the potential risks of GM crops, while others emphasize their potential benefits. Just what are the issues and how can we address them?

What is the current environmental situation?

A growing population, global warming, and loss of biodiversity have a tremendous impact on our environment.

By year 2050, there will be 9.5 billion people living on this planet. This means that in less than 50 years, world population is expected to increase by 3 billion. Feeding these people will mean massive changes in the production, distribution, and stability of food products.

Unfortunately, cropland and population are not uniformly distributed. For example, China has only 1.4% of the world's productive land but 20-25% of the world's population.[1] This situation is further aggravated by diminishing cropland due to erosion, fewer renewable resources, less water, and a reduced population working the land.

The destruction of wilderness and forests, and continued use of coal and oil have led to a steady increase in carbon dioxide levels, resulting in global warming. It is predicted that the average global temperature will rise by 1.4 – 5.8°C by 2100, with increasing fluctuations in weather conditions. Climate change can radically alter rainfall patterns and therefore require the migration of people and shifts in agricultural practices.

Further, an increasing human population is responsible for wilderness destruction, water quality problems, and diversion of water. The loss of habitat has resulted in many species being displaced.

Thus, to conserve forests, habitats, and biodiversity, it is necessary to ensure that future food requirements come only from cropland currently in use.

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Pocket K

GM crops *and the Environment*

Global Knowledge Center on Crop Biotechnology

What are the environmental benefits of GM crops?

One of the significant environmental benefits of GM crops is the dramatic reduction in pesticide use, with the size of the reduction varying between crops and introduced trait.

- A study assessing the global economic and environmental impacts of biotech crops for the first twenty one years (1996-2016) of adoption showed that the technology has reduced pesticide spraying by 671.2 million kg and has reduced environmental footprint associated with pesticide use by 18.4%. The technology has also significantly reduced the release of greenhouse gas emissions from agriculture equivalent to removing 16.75 million cars from the roads.[2]
- According to a meta-analysis on the impacts of GM crops, GM technology has reduced chemical pesticide use by 37 percent.[3]
- A study of U.S. maize and soybean farmers from 1998 to 2011 concluded that adopters of herbicide tolerant maize used 1.2% (0.03 kg/ha) less herbicide than non-adopters, and adopters of insect resistant maize used 11.2% (0.013 kg/ha) less insecticide than non-adopters.[4]
- In China, use of Bt cotton resulted in pesticide use reduction of 78,000 tons of formulated pesticides in 2001. This corresponds to about a quarter of all the pesticides sprayed in China in the mid-1990s.[5] Furthermore, another study covering data collected from 1999 to 2012 showed that Bt cotton adoption has caused a significant reduction in pesticide use.[6]
- The use of Bt cotton can substantially reduce the risk and incidence of pesticide poisonings to farmers.[7]
- Herbicide tolerant crops have facilitated the continued expansion of conservation tillage, especially no-till cultivation system, in the USA. The adoption of conservation and no-till cultivation practices saved nearly 1 billion tons of soil per year.[8]
- Biotech cotton has been documented to have a positive effect on the number and diversity of beneficial insects in the US and Australian cotton fields.[9]
- Adoption of Bt corn in the Philippines did not show an indication that Bt corn had negative effect on insect abundance and diversity.[17]

How are GM crops assessed for environmental safety?

GM crops are thoroughly evaluated for environmental effects before entering the marketplace. They are assessed by many stakeholders in accordance with principles developed by environmental experts around the world.[10,11,12] Among those who conduct risk assessment procedures are the developers of GM crops, regulatory bodies, and academic scientists.

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Herbicide tolerant soybeans were approved for environmental release as early as 1994.

Most countries use similar risk assessment procedures in considering the interactions between a GM crop and its environment. These include information about the role of the introduced gene, and the effect that it brings into the recipient plant. Also addressed are specific questions about unintentional effects such as:

- impact on non-target organisms in the environment
- whether the modified crop might persist in the environment longer than usual or invade new habitats
- likelihood and consequences of a gene being transferred unintentionally from the modified crop to other species

Further, an increasing human population is responsible for wilderness destruction, water quality problems, and diversion of water. The loss of habitat has resulted in many species being displaced.

Thus, to conserve forests, habitats, and biodiversity, it is necessary to ensure that future food requirements come only from cropland currently in use.

What are the potential risks?

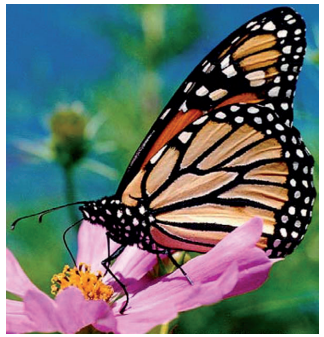
Potential of the introduced genes to outcross to weedy relatives as well as the potential to create weedy species

Out-crossing is the unintentional breeding of a domestic crop with a related plant. A major environmental concern associated with GM crops is their potential to create new weeds through out-crossing with wild relatives, or simply by persisting in the wild themselves.

The potential for the above to happen is assessed prior to introduction, and is monitored after the crop is planted as well. A ten-year study initiated in 1990 demonstrated that there is no increased risk of invasiveness or persistence in wild habitats for GM crops (oilseed rape, potatoes, corn, and sugar beet) and traits (herbicide tolerance, insect protection) tested when compared to their unmodified counterparts.[13] The researchers stated, however, that these results "do not mean that genetic modifications could not increase weediness or invasiveness of crop plants, but they do indicate that productive crops are unlikely to survive for long outside cultivation." It is therefore important, however, as regulations require, to evaluate individual GM crops on a case-by-case basis, both prior to release and after commercialization.

Direct effects on non-target organisms

In May 1999, it was reported that pollen from Bacillus thuringiensis (Bt) insect resistant corn had a negative impact on Monarch butterfly larvae. This report raised concerns and questions about potential risks to Monarchs and perhaps other non-target organisms. Some scientists, however, urged caution over the interpretation of the study because it reflects a different situation than that in the environment. The author indicated "Our study was conducted in the lab and, while it raises an important issue, it would be inappropriate to draw any conclusions about the risk to Monarch populations in the field solely on these initial results." In 2001, a study published in PNAS concluded that the impact of Bt corn pollen on Monarch butterfly populations is negligible.[16]



"Biotech corn is not a serious threat to Monarchs", US EPA (Photo by PB Sutherland)

A report from the US Environmental Protection Agency (EPA) indicated that the "data provide a weight of evidence indicating no unreasonable adverse effects of Bt proteins expressed in plants to non-target wildlife." Furthermore, a collaborative research effort by North American scientists has concluded that in most commercial hybrids, Bt expression in pollen is low, and laboratory and field studies show no acute toxic effects at any pollen density that would be encountered in the field.[13] A *Nature* publication of Losey, 1999; and lab experiments on force-fed predators and extensive field work demonstrated no significant impact on Monarch Butterfly populations.[18]

Development of insect resistance

Another concern over the use of Bt crops is that it will lead to the development of insect resistance to Bt. Insect resistance management plans have been developed by government, industry, and scientists to address this issue. These plans include a requirement that every field of insect resistant crops must have an associated refuge of non-GM crops in order for the insects to develop without selection to the insect resistant varieties.

Additional resistance management practices are also being developed by scientists all over the world. These must be performed in line with post-approval monitoring, where GM crops, as well as their immediate environment, will be constantly evaluated for changes even after the crop has been released.

Conclusion

The environmental and ecological concerns potentially associated with GM crops are evaluated prior to their release. In addition, post-approval monitoring and good agricultural systems need to be in place to detect and minimize potential risks, as well as to ensure that GM crops continue to be safe after their release. Comparisons among GM, conventional, and other agricultural practices, such as organic farming, will bring to light the relative risks and benefits of adopting GM crops.