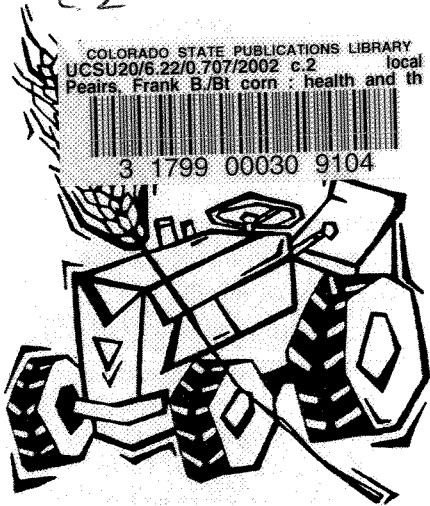


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C R O P S E R I E S

# PRODUCTION

**Bt Corn: Health and the Environment** no. 0.707  
by F.B. Peairs<sup>1</sup>

## Quick Facts...

*Bacillus thuringiensis* (Bt) is a soil bacterium that produces insecticidal toxins.

Genes from Bt can be inserted into crop plants to make them capable of producing an insecticidal toxin and therefore resistant to certain pests.

There are no known adverse human health effects associated with Bt corn.

Bt corn can adversely affect non-target insects if they are closely related to the target pest, as is the case with Monarch butterfly. These adverse effects are considered minor, relative to those associated with the alternative of blanket insecticide applications.

New technology allows us to improve crop varieties by adding genes from other species. This is useful because we can alter traits, such as insect resistance, that might not naturally exist in the crop species, or that might be difficult to transfer within the crop species using classical plant breeding techniques. One successful application of this new technology is the development of corn hybrids that are resistant to certain insect pests because of the addition of a gene from a natural soil bacterium.

Although these corn hybrids are highly effective in controlling insect pests, their use has raised concerns. The following series of questions and answers provides an overview of these insect-resistant corn hybrids and addresses some of the health and environmental issues associated with their use. Fact sheet 0.708, *Managing Corn Pests with Bt Corn* addresses the use of these hybrids in pest management.

## Questions and Answers

### Q: What is Bt?

A: Bt is shorthand for common soil-inhabiting bacteria called *Bacillus thuringiensis*. Bt also refers to insecticide products made from these bacteria.

### Q: Where is Bt normally found?

A: Bt is widely distributed. In addition to being found in many soils around the world, it is also found on the leaves of plants and in stored grain.

### Q: What does Bt have to do with insect pests?

A: Some strains of Bt kill insects with toxins called *insecticidal crystal proteins* or *delta endotoxins*. This group of toxins is considered relatively harmless to humans and most non-pest species. However, other toxins produced by Bt have a broader spectrum of toxicity.

### Q: How is the insect exposed to Bt?

A: Delta endotoxins are stomach poisons that must be eaten by the insect in order to be effective. After ingestion, the toxin is activated in the highly alkaline insect midgut.

### Q: How does Bt kill insects?

A: Delta endotoxins rapidly paralyze the insect's digestive system, so damage to the plant stops soon after the insect is exposed to the crystals. Mortality may take several days, so the effects of delta endotoxins are very different from what we expect from conventional insecticides.

### Q: What pests are controlled by Bt?

A: Different strains (about 280 are known) of *Bacillus thuringiensis* produce different forms of delta endotoxins—many are toxic to caterpillars (e.g., European corn borer), while others are toxic to flies (e.g., mosquitoes) or beetles (e.g., corn rootworm).



**How can I find out more about Bt corn?**

Information about specific hybrids is available from seed dealers and seed companies. Several useful publications and Web sites are:

Anonymous. 1999. *An Evaluation of Insect Resistance Management in Bt Field Corn: A Science-Based Framework For Risk Assessment and Risk Management. Report of an Expert Panel.* 1999. International Life Sciences Institute, Health and Environmental Sciences Institute. Washington, D.C. ([www.ilsa.org](http://www.ilsa.org))

K. R. Ostlie, W. D. Hutchinson & R. L. Hellmich (eds.). 1997. *Bt Corn and European Corn Borer: Long-Term Success Through Resistance Management.* North Central Regional Extension Publication NCR 602. University of Minnesota, St. Paul, MN. ([www.extension.umn.edu/distribution/cropsystems/DC7055.html](http://www.extension.umn.edu/distribution/cropsystems/DC7055.html))

R. J. Wright, T. E. Hunt, J. F. Witkowski, B. D. Siegfried, and J. E. Foster. 2000. *Choosing a Bt Transgenic Corn Hybrid.* Nebraska Cooperative Extension NF00-409. ([www.ianr.unl.edu/pubs/fieldcrops/nf409.htm](http://www.ianr.unl.edu/pubs/fieldcrops/nf409.htm))

The Agbios (a Canadian consulting company) Web site is an informative agricultural biotechnology resource with a searchable database ([www.agbios.com/default.asp](http://www.agbios.com/default.asp)).

The American Seed Trade Association has a biotechnology section at their Web site, including information on marketing Bt corn ([www.amseed.com/newsQA.asp?qatype=Biotechnology](http://www.amseed.com/newsQA.asp?qatype=Biotechnology)).

The Biotechnology Research and Education Initiative at the University of Kentucky maintains a good general biotechnology site, including information on Bt corn issues ([www.ca.uky.edu/brei/](http://www.ca.uky.edu/brei/)).

Colorado State University maintains the Transgenic Crops: An Introduction and Resource Guide site, a very good general site on transgenic crops with many links to additional informative sites ([www.colostate.edu/programs/lifesciences/TransgenicCrops/](http://www.colostate.edu/programs/lifesciences/TransgenicCrops/)).

**Q: Are Bt insecticides new?**

**A:** Bt insecticides, consisting of dormant Bt and delta endotoxin, have been available commercially and used in agriculture for more than 30 years (e.g., Bactimos, Biobit, Dipel, Javelin, Teknar, Vectobac). These are used primarily for control of caterpillar pests of various crops, as well as mosquito and black fly larvae.

**Q: Is Bt safe?**

**A:** The delta endotoxins are considered to be much more selective and safer for humans and nontarget organisms than most conventional insecticides because they attack sites that are found only in a few groups of insects. Commercial Bt insecticides are classified as Generally Regarded as Safe (GRAS) by the EPA, and are approved for most organic certification programs.

**Q: What is Bt corn?**

**A:** Production of delta endotoxin is controlled by a single gene in the bacteria. A modified version of this gene can be placed in corn plants. Corn plants containing this gene can produce delta endotoxin and therefore be toxic to insects that are susceptible to that form of the protein.

**Q: Why use the Bt gene in corn?**

**A:** Delta endotoxins sprayed on plants break down quickly when exposed to UV light. Delta endotoxins produced in the plant are protected from UV light. Also, several of the major pests of corn are difficult and expensive to control with conventional insecticides, but are susceptible to delta endotoxins produced in plant tissues. The biotechnology to insert the toxin producing Bt gene into corn is available.

**Q: Is the entire Bt corn plant toxic?**

**A:** It depends. Two factors, the *event* and the *promoter*, control where delta endotoxins are produced in the plant and in what amounts. Different seed companies use different *events* and *promoters*, so their hybrids will also be different in what plant tissues produce delta endotoxins.

The insertion *event* is the physical act of putting the Bt gene into the corn plant's genetic material. This is when the physical location of the Bt gene is determined (which chromosome, what part of the chromosome, etc). Gene location affects where in the plant delta endotoxins are produced and how much delta endotoxin is produced. Currently, we do not have the technology to control Bt gene location, so each *event* results in plants that differ in where and in how much delta endotoxin is produced.

The *promoter* is a genetic switch that tells the inserted Bt gene when and where to produce delta endotoxins. Several different *promoters* are available and the choice of *promoter* also affects where and how much delta endotoxin is produced in the corn plant, leading to differences among hybrids.

**Q: How many kinds of Bt corn are there?**

**A:** There are many different Bt corn hybrids available, however, each contains only one of the events described above.

**Q: I've heard that Bt corn is toxic to Monarch butterflies. Is this true?**

**A:** The caterpillar stage of the Monarch feeds on milkweed. Laboratory studies show some mortality in Monarch caterpillars fed milkweed leaves covered with Bt corn pollen. Several questions still need to be answered before the risk to Monarch butterflies can be determined.

**Q: Do Monarch butterflies lay eggs on milkweed plants in or near cornfields?**

**A:** Yes. Early indications are that more eggs are laid in and near cornfields than in the other environments that were studied.

**Q: Is Monarch caterpillar survival lower on milkweed plants in Bt cornfields compared to non-Bt cornfields?**

**A:** No. There were no differences in survival at several locations in the Midwest and Ontario. The exception to this is Bt corn transformed with the now discontinued event 176.

**Additional Resources:**

The Environmental Protection Agency maintains a biopesticide section at their Web site including information about Bt corn ([www.epa.gov/pesticides/biopesticides/](http://www.epa.gov/pesticides/biopesticides/)).

The Information Systems for Biotechnology site at Virginia Tech is a good general site with a monthly news report, databases, and extensive links to other biotechnology sites ([www.nbiap.vt.edu/](http://www.nbiap.vt.edu/)).

The National Academy of Sciences has several papers on the influence of Bt corn pollen on monarch butterflies ([www.pnas.org/papbyrecent.shtml](http://www.pnas.org/papbyrecent.shtml)).

The National Corn Growers Association has a biotechnology section at their Web site ([www.ncga.com/biotechnology/main/index.html](http://www.ncga.com/biotechnology/main/index.html)).

**Q: Is Monarch caterpillar survival better when corn borers are controlled with Bt corn or with insecticides?**

**A:** Studies in both field and sweet corn showed lower Monarch caterpillar survival in insecticide-treated fields compared to untreated fields planted to Bt corn hybrids.

**Q: What is a lethal dose of Bt corn pollen?**

**A:** This depends on the event. The most toxic pollen is produced by event 176 (no longer available commercially), which has 15 to 25 times more delta endotoxin per pollen grain than event MON810. The lethal dose (LD<sub>50</sub>) for event 176 pollen is about 2500 pollen grains per in<sup>2</sup> of milkweed leaf. No observable adverse effects were found at 850 grains (event 176) per in<sup>2</sup> of milkweed leaf. No acute effects have been identified for pollen from plants with event MON810 or event Bt11. However, additional questions have been raised regarding the toxicity of anthers to Monarch caterpillars and other nontarget caterpillars.

**Q: Do lethal doses of Bt corn pollen occur on milkweed plants within Bt cornfields?**

**A:** Bt corn pollen counts within Ontario fields averaged 500 grains per in<sup>2</sup> of milkweed leaf. The highest counts in this study were just below 2500 grains per in<sup>2</sup> of milkweed leaf.

**Q: Do lethal doses of Bt corn pollen occur on milkweed plants near Bt cornfields?**

**A:** Corn pollen is relatively heavy and does not travel far. Milkweed plants three feet from Ontario cornfields averaged 180 pollen grains per in<sup>2</sup> of milkweed leaf and milkweed plants 15 feet from the field averaged nine pollen grains per in<sup>2</sup> of milkweed leaf. Rainfall greatly reduces pollen densities on milkweed plants in cornfields.

**Q: Are there sublethal effects for Monarch caterpillars that feed on Bt corn pollen?**

**A:** Little is known about sublethal effects such as reduced growth or delayed development. However, it has been noted that Monarch caterpillars consume less when fed milkweed leaves containing Bt corn pollen than on clean leaves.

**Q: Are Monarch caterpillars feeding on milkweed leaves during pollen shed?**

**A:** The more synchrony there is between pollen shed and the presence of small Monarch caterpillars on milkweed, the greater the risk from Bt corn. Currently, researchers believe that there is little overlap between the two, but both are variable events influenced by weather and location so there may be situations where they are well synchronized.

**Q: Is there anything that can be done to protect the Monarch butterfly from Bt corn pollen in Colorado?**

**A:** The threat to Monarchs in Colorado is quite low since the Monarch butterfly is rare in our state. Where Monarchs are more common, the EPA suggests planting non-Bt corn as a pollen trap around the field or consider prevailing wind direction and likely Monarch habitat locations when deciding where Bt corn and non-Bt corn should be planted. These suggestions would also serve to minimize the risk to other nontarget caterpillars that might be of concern.

**Q: Are there other insects that are threatened by Bt corn?**

**A:** Many species of caterpillars occur in and around cornfields during the growing season, and might be affected by Bt corn. This will be a continuous concern as new events are introduced in corn and as other modified crops are developed.

One Midwest study showed that black swallowtail larvae were unaffected by Bt corn pollen, but another indicated that event 176 pollen could have

sublethal effects on this species. However, the detailed set of studies currently underway on the Monarch butterfly have not been undertaken for this insect.

One European study showed that green lacewing larvae (a predator found in corn) fed European corn borers from Bt corn had greater mortality than lacewing larvae fed corn borers from non-Bt corn.

**Q: Is it true that the roots of Bt corn plants leak delta endotoxins into the soil?**

**A:** Yes, this has been demonstrated in several laboratory studies. However, the implications for various soil organisms are unclear. Since Bt is a very common soil bacterium, it is likely that exposure of these organisms to delta endotoxins is common. The levels of delta endotoxins measured in the lab studies were at least 10 times below those that cause observable effects in important soil organisms such as earthworms and springtails.

**Q: The alternative to Bt corn seems to be the use of conventional insecticides. Which is more harmful to nontarget insects, such as the Monarch butterfly?**

**A:** Very few studies have been conducted on the risk of Bt corn to nontarget insects. Preliminary results from these indicate that the risks are relatively small. Also, millions of acres of forests have been treated for gypsy moth and other pests with Bt insecticides over the past 30 years with little documented effect on nontarget species. On the other hand, the hazards of conventional insecticides to many different nontarget insect species are very well documented.

**Q: I've heard that Bt corn is a health threat because it causes allergic responses in some people. Is this true?**

**A:** Some experimental transgenic plants have caused allergic responses. The EPA requires several food allergen tests as part of the registration process for transgenic crops containing pesticidal substances. The first test measures the length of time that the potential allergen survives in an acid environment. Longer survival times indicate more likelihood of surviving the digestion process and being absorbed into the blood stream, which is the first step in food allergenicity.

The Cry 9C delta endotoxin produced by the Starlink event survives significantly longer in an acid environment than the other registered delta endotoxins. For this reason Starlink corn hybrids were approved only for use as animal feed and not for human consumption, pending further allergenicity testing.

Delta endotoxins produced by the currently available events all are rapidly broken down in the stomach and thus are not potential food allergens.

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