

# Bt Corn: Health and the Environment

Fact Sheet No. 0.707

Crop Series | Production



by F.B. Peairs\*

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 toxin. Mortality may take several days, so the effects of delta endotoxins are very different from what we expect from conventional insecticides.

### Q: Are there other types of Bt toxins?

**A:** Another type of Bt toxins are called vegetative insecticidal proteins, or VIPs. VIPs are also considered relatively safe for non-pest species, however, other classes of toxins produced by Bt have a broader spectrum of toxicity.

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

**A:** Different strains (about 600 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).

### 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

## 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.

\*F.B. Peairs, Colorado State University Extension entomologist and professor, bioagricultural sciences and pest management. 8/10

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 and VIPs 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 and VIPs 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 or VIP and therefore be toxic to insects that are susceptible to that form of the protein.

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

**A:** BT toxins sprayed on plants break down quickly when exposed to UV light. BT toxins 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 Bt toxins produced in plant tissues. The biotechnology to insert toxin producing Bt genes into corn is available.

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

**A:** It depends. Two factors, the *event* and the *promoter*, control where toxins 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 Bt toxins.

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 toxins are produced and how much Bt toxin 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 toxin is produced.

The *promoter* is a genetic switch that tells the inserted Bt gene when and where to produce Bt toxins. 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 or two 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.

**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 to Monarch caterpillars?**

**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.

A number of studies have been conducted on the influence of Bt corn on natural enemies. Results have been variable, affected by factors such as the event studied and whether comparisons were made with insecticide-treated or untreated controls.

**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 Bt toxins is common. The levels of Bt toxins 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:** Results from studies of non-target effects 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.

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

**Q: Are there other risks from Bt corn pollen?**

**A:** Yes. Bt corn pollen can contaminate adjacent non-Bt corn crops. This can be an issue if the event(s) in this pollen is (are) not approved for international trade. It also can be an issue for certified organic producers. Planting at least 150 feet apart will avoid most of these problems under Colorado conditions.

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

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

AgBioForum: The Journal of Agrobiotechnology Management and Economics, [www.agbioforum.missouri.edu](http://www.agbioforum.missouri.edu). This is an online, scientific journal devoted to agricultural biotechnology issues.

Ag Biosafety, University of Nebraska, Lincoln. <http://agbiosafety.unl.edu/about.shtml>. This is dedicated to addressing current issues in crop biotechnology and food safety.

Agricultural Biotechnology, The Pew Charitable Trusts, [www.pewtrusts.org/our\\_work\\_detail.aspx?id=442](http://www.pewtrusts.org/our_work_detail.aspx?id=442). This site hosts information developed through 2007 by the The Pew Initiative on Food and Biotechnology.

GM Crop Database. Center for Environmental Risk Assessment (CERA), ILSI Research Foundation, Washington D.C. [http://cera-gmc.org/index.php?action=gm\\_crop\\_database](http://cera-gmc.org/index.php?action=gm_crop_database). This is a searchable database for GM traits, as well as other novel traits produced through other plant breeding methods.

Information Systems for Biotechnology (ISB): A National Resource for Agbiotech Information, Virginia Tech., [www.isb.vt.edu/](http://www.isb.vt.edu/). This site provides documents and searchable databases pertaining to the development, testing and regulatory review of genetically modified plants, animals and microorganisms within the US and abroad.

Regulating Biopesticides, United States Environmental Protection Agency, [www.epa.gov/oppbppd1/biopesticides/](http://www.epa.gov/oppbppd1/biopesticides/). This site explains the regulatory process for biopesticides, including Bt corn events.

The International Service for the Acquisition of Agribiotech Applications, [www.isaaa.org/kc/](http://www.isaaa.org/kc/). This comprehensive website is pro-biotechnology, but does contain a wealth of up-to-date information.

USDA, National Agricultural Library, Biotechnology information page. [http://riley.nal.usda.gov/nal\\_display/index.php?info\\_center=8&tax\\_level=2&tax\\_subject=8&level3\\_id=0&level4\\_id=0&level5\\_id=0&topic\\_id=1067&placement\\_default=0](http://riley.nal.usda.gov/nal_display/index.php?info_center=8&tax_level=2&tax_subject=8&level3_id=0&level4_id=0&level5_id=0&topic_id=1067&placement_default=0). This site contains links to many agricultural biotechnology information sources.

## Acknowledgments

I would like to thank Gary Hein, University of Nebraska, Scottsbluff; Jerry Alldredge, Assefa Gebre-Amlak, Bruce Bosley, Randy Buhler, Pat Byrne, Jerry Johnson, Ron Meyer, Stan Pilcher, Elaine Roberts, and John Shanahan all of Colorado State University; and Phil Sloderbeck, Kansas State University, Garden City, for reading and commenting on earlier versions.