Colorado State University
Extension

Managing Corn Pests with Bt Corn

Fact Sheet No. **0.708** Crop Series | **Production**

by F.B. Pears*

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. Such hybrids are referred to as "transgenic" hybrids, although not all transgenic hybrids contain insect resistance traits.

Although these insect-resistant transgenic 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 their use in pest management. Fact sheet 0.707, *Bt Corn: Health and the Environment* addresses what bacteria are involved; the insecticidal toxins they produce; crop transformation; and health and environmental issues that have developed from the use of this technology.

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: 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. They are considered relatively harmless to humans and most non pest species.

Q: Are there other types of Bt toxins?

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

Q: What is Bt corn?

A: Production of delta endotoxins is controlled by a single gene in the bacteria. Modified versions of these genes can be placed in corn plants. Corn plants containing the gene can produce delta endotoxin and therefore be toxic to insects that are susceptible to that form of the protein.

Q: Why use Bt genes 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 major corn pests are difficult and expensive to control with conventional insecticides, but are susceptible to delta endotoxins produced in plant tissues. And, 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 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

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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 toxins and therefore resistant to certain pests.
- Corn hybrids with one or more Bt genes (Bt corn) are resistant to some important pests.
- Bt corn hybrids are a highly effective and economical alternative to conventional insecticide treatments, if targeted pest activity is at economically significant levels.

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Table 1. Types of BT corn.

Bt Event	Trade Name***	Toxin Type
5307	Agrisure Duracade	Cry3A-Cry1Ab**
Bt11	Agrisure CB	Cry1Ab*
DAS59122-7	Herculex RW	Cry34Ab1, Cry35Ab1**
MIR162	Agrisure Viptera	VIP3Aa20*
MIR604	Agrisure RW	modified Cry3Aa**
MON810	YieldGard Corn Borer	Cry1Ab*
MON88017	YieldGard VT Rootroom	Cry3Bb1**, Cry1A.105, Cry2A6*
MON89034	Yieldgard VT Pro, Genuity VT Double Pro	
TC1507	Herculex CB (Mycogen, Pioneer)	Cry1F*, Cry1Ab* + modified Cry3Aa**
Bt11 + MIR604	Agrisure CB/LL/RW, Agrisure 3000GT	
Bt11 + MIR162	Agrisure Viptera 3110	Cry1Ab* + VIP3Aa20*
Bt11 + MIR604 + MIR162	Agrisure Viptera 3111	Cry1Ab* + VIP3Aa20* + modified Cry3Aa**
Bt11 + MIR162 + TC1507	Agrisure Viptera 3220	Cry1Ab* + VIP3Aa20* + Cry1F*
MON810 + MON88017	YieldGard VT Triple	Cry1Ab* + Cry3Bb1
MON810 + TC1507	Optimum Intrasect	Cry1Ab* + Cry1F*
TC1507 + 149B1	Herculex XTRA	Cry1F + Cry34Ab1, Cry35Ab1
MON88017 + MON89034	Genuity VT Triple Pro	Cry3Bb1** + Cry1A.105, Cry2A6*
MON810 + TC1507 + DAS59122-7	Optimum Intrasect XTRA	Cry1Ab* + Cry1F* + Cry34Ab1, Cry35Ab1**
MON88017 + MON89034 + DAS59122-7 + TC1507	SmartStax	Cry1A.105, Cry2A6* + Cry1F* + Cry3Bb1** + Cry34Ab1, Cry35Ab1**
5307 + Bt11 + MIR604 + TC1507	Agrisure Duracade 5122	Cry3A-Cry1Ab*,** + Cry1Ab* + modified Cry3Aa** + Cry1F*
5307 + Bt11 + MIR604 + TC1507 + MIR162	Agrisure Duracade 5222	Cry3A-Cry1Ab*,** + Cry1Ab* + modified Cry3Aa** + Cry1F* + VIP3Aa20*

*Targets caterpillars.

**Targets rootworms.

***Some may include herbicide tolerance traits, as well.

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: Have VIPs been used in corn?

A: VIP events have been used successfully for many years in cotton and now are available in corn (Table 1).

Q: How many kinds of Bt corn are there?

A: There are many different Bt corn hybrids available, and some may contain both corn borer and corn rootworm events. The available events are summarized in Table 1.

Q: Does each hybrid contain just one event?

A: This is true for some hybrids. However, the trend is towards having two events each for corn borer, rootworm, and herbicide tolerance in a single hybrid.

Q: Will all Bt corn hybrids give the same level of control?

A: The level of control of targeted pests and the spectrum of control provided by a hybrid is a function of the event(s) it contains. It is better to compare insect control by event rather by hybrid. For example, corn borer control can be expected to be similar among hybrids containing the Mon810 event.

Select hybrids that will work well in your area and ask for insect control data that are specific for the events that these hybrids contain.

Q: Will Bt corn work well in my area?

A: The Bt traits should not affect hybrid performance. If the conventional version of the hybrid works well, the Bt version should work well too.

Q: Is Bt the only trait genetically engineered into corn?

A: Other hybrids with genetically engineered traits, such as herbicide resistance and drought tolerance, are available. Many other traits are in development and will become available in the future.

Q: Is corn the only crop genetically engineered with Bt?

A: No, several other crops have been modified to produce Bt toxins. However, corn and cotton make up most of the commercial use.

Q: What kind of European corn borer control can I expect from Bt corn?

A: Control of first generation is expected to be excellent and possibly better than would be expected from a single well-timed insecticide application. Control of second generation European corn borer is expected to be substantially better than generally would be expected from a single well timed insecticide treatment.

Q: Are there other advantages to using Bt corn instead of an insecticide to control corn borers?

A: Bt corn will control corn borers without directly affecting predators and other beneficial insects. This should make management of other pests such as spider mites easier, although there are no field data to support this claim.

Q: Are there disadvantages to using Bt corn compared to conventional corn borer control?

A: There will be an additional cost to Bt corn seed regardless of whether there is an economic corn borer infestation. Conventional chemical control allows you to wait and see if an infestation develops before investing in insect management. Also, compliance with refuge requirements (see below) may complicate planting, harvest and pest management activities.

Q: What kind of corn rootworm control can I expect from Bt corn?

A: Most university studies have shown corn rootworm control with Bt events to be superior to soil insecticides and seed treatments except under conditions of very high corn rootworm pressure. Under such conditions performance with older events is more similar to that of soil-applied insecticides, while remaining superior to seed treatments. However, newer events and event combinations tend to maintain a performance advantage over conventional treatments.

Q: Are there other advantages to using Bt corn instead of an insecticide to control corn rootworms?

A: Bt corn would eliminate the need for the specialized equipment needed to apply soil insecticides and the need to handle these chemicals.

Q: Are there disadvantages to using Bt corn compared to conventional corn rootworm control?

A: Compliance with refuge requirements (see below) may complicate planting, harvest and pest management activities.

Q: I have experienced failures of rootworm insecticides. Are the rootworm events more reliable than insecticides?

A: This is a difficult comparison to make. Conventional insecticide application failures have been reported many times, but few of these have been associated with genetic resistance in rootworm populations. Rootworm control failures with one event have been documented and could spread to include other rootworm events. These failures are due to genetic adaptation by the rootworm. The cause of other event failures is unknown.

Q: What about the other corn pests I have to deal with every year?

A: Events targeting corn rootworms, corn borers, western bean cutworm, and several other caterpillar species are available. No events are available for spider mites.

Q: Can I plant Bt corn and forget about insects and mites?

A: No, Bt corn will not let you forget completely about insect pests. Scouting and management will still be necessary for some pests. Table 2 shows the major corn pests and the expected effect of commercially available events. Also, pests in refuge acres need to be managed conventionally.

Q: Are there other disadvantages to using Bt corn compared to conventional pest management practices?

A: There may be difficulty in marketing Bt corn destined for international markets. The international marketing situation changes rapidly, so it is impossible to know how the rules might change between hybrid selection and harvest. This is most commonly a problem with newly approved events.

Q: What will be the additional cost for Bt corn seed?

A: It should cost from $5 (dry land) to $10 (irrigated) per acre to use a given Bt corn event, depending on seeding rates. There may be additional costs for other traits. In some hybrids, one or both of the Bt traits may be available only in combination (stacked traits) with other traits such as herbicide resistance.

Q: Where should I use Bt corn in my operation?

A: Bt corn should be used only where the risk of infestation by a targeted pest is high.

Table 2. Major corn pests and the expected effect with Bt corn.

Corn Pest	Effect of Bt Corn	Comments
Armyworm	Variable	Data lacking.
Corn rootworm adults	No control	
Corn rootworm larvae	Control	Only with corn rootworm specific events. Field resistance reported for events containing Cry3Bb1.
Corn leaf aphid	No control	Less insecticide use may reduce aphid activity.
Corn earworm	Control	Control with Cry1F and VIP3Aa20.
Cutworms	Variable	Cry1F and VIP3Aa20 events effective against black cutworm. Data lacking on other species.
European corn borer	Control	No control with single events targeting corn rootworm or VIP3Aa20.
Fall armyworm	Variable	Cry1F and VIP3Aa20 events more effective.
Grasshoppers	No control	
Southwestern corn borer	Control	No control with single events targeting corn rootworm.
Spider mites	No control	Less insecticide use may reduce mite activity.
Western bean cutworm	Variable	Cry1F and VIP3Aa20 events effective.
Wireworms	No control	

Q: Where are the high risk areas for European corn borer?

A: Colorado State University Extension entomologists recognize the following European corn borer risk areas within the Golden Plains area (Kit Carson, Phillips, Washington and Yuma counties) based on more than a decade of pest survey information. Pest survey data are insufficient to characterize European corn borer risk for other parts of the state.

Zone 1 (Burlington, Bonny Dam, Kirk) is characterized by heavy soils and consistently low insect light trap catches. Areas in this zone generally are not expected to have economic European corn borer infestations, although growers in the Kirk area experience occasional problems. Growers in Zone 1 should select well adapted non Bt corn hybrids, scout for insect pest problems and apply appropriate insecticides if justified. The exception might be the Kirk area because it has a long (four to five week) second generation flight in some years, increasing the probability that late planted or late maturing varieties will experience economic infestation. Bt corn hybrids might be an appropriate choice for these situations.

Zone 2 (Yuma, Clarkville, Holyoke) has a high probability of late planting or late maturing varieties due to heavy soils. These areas also have a consistent history of a prolonged second generation flight that result in economic infestations. The Bt trait would be an appropriate choice for late planted or late maturing hybrids in these areas. The prolonged flight makes treatment decisions difficult. The infestations accumulated over the season are economically significant, but not enough of the infestation occurs in any two week period to justify the use of an insecticide. The first generation flight is consistent enough in these areas that Bt hybrids might be considered for early planting situations. Although there is not a consistent need for Bt hybrids in this zone, it will be important to consider resistance management requirements when selecting hybrids and their acreage allocation.

Zone 3 (Eckley, Wray, Wauneta – north of Hwy 34 and east of Yuma) is characterized by light soils, relatively uniform crop maturity, and consistently large first and second generation European corn borer flights. Also, second generation flights typically extend over long periods of time. Economic infestations from either generation are likely and often both generations need treatment in the same field. It's often difficult to obtain adequate second generation control with a single insecticide application. The use of Bt corn hybrids are recommended for this area, regardless of planting date or maturity.

Q: If I am not in one of these risk areas, how can I to justify switching to Bt corn to control corn borers?

A: Take a look at your average expenditures for insect management (scouting, insecticides and application) and your average losses to corn borers over the last five years. Your annual total of corn borer management costs and crop value lost should be similar to the cost of switching to a Bt corn event targeting corn borer.

Q: Where are the high risk areas for corn rootworm?

A: Corn rootworm risk is considered high only in continuous corn. However, continuous corn grown on sandy soils is considered a lower risk.

Q: How can I justify switching to Bt corn for corn rootworm control?

A: If you currently use a soil insecticide or control adult corn rootworms to prevent egg laying, you are likely justified in using Bt corn for corn rootworm control.

Q: Should I plant all of my corn acreage to Bt corn?

A: No! The EPA has published guidelines on resistance management (refuge strategy) that affect how much you can plant. Details on these guidelines are in the EPA document *Biopesticides Registration Action Document: Bacillus thuringiensis Plant Incorporated Protectants* (www.epa.gov/pesticides/biopesticides/pips/bt_brad.htm). How much to plant also depends on the severity and the consistency of your corn borer or corn rootworm problems. Your average annual total of management costs and crop value lost to these insects over the last five years will give you an idea of how much to spend on Bt corn seed premiums. Use this seed in situations with higher pest risk (with European corn borer, for example, in the earliest and latest planted fields).

Q: Will corn borers or corn rootworms eventually overcome the delta endotoxins produced by Bt corn, as has been observed with greenbug resistance in sorghum hybrids or with many insects and various insecticides?

A: Insects can develop resistance to Bt toxins. Resistance in diamondback moth and other vegetable pests to commercial Bt insecticides has developed in several parts of the world. This is also a major concern for all Bt modified crops because they put so much selective pressure on the pest. However, apart from western corn rootworm, no cases of resistance in any targeted corn or cotton pests have been documented since 1996 when Bt crops first were grown extensively in the United States.

Q: What is being done to avoid corn borer resistance to Bt corn?

A: University researchers, the seed industry, and the EPA are working together to develop resistance management plans that are effective and practical. They are based on the high dose and the refuge strategies.

Q: What is the high dose strategy?

A: The idea is to use Bt corn hybrids that produce enough delta endotoxin to kill even partially resistant corn borers. Killing partially resistant corn borers and preventing their mating greatly delays the development of resistance. High dose events currently are not available for corn rootworms.

Q: How does this strategy affect producers?

A: Some events are not as high dose as others and some areas are considered to be more likely to develop insect resistance than others. The EPA may prohibit the sale of certain events in certain regions. In the past, sales of two events were prohibited in some southeast Colorado counties.

Q: What is the refuge strategy?

A: If a certain acreage (refuge) is planted with non Bt hybrids then any corn borers or corn rootworms coming out of these areas will be susceptible to Bt. They will mate with any survivors from the Bt corn and preserve the genetic susceptibility of the overall population.

Q: How does the refuge strategy affect producers?

A: Current EPA policy restricts growers to a certain percentage Bt corn acreage for either corn rootworm or corn borer control. Hybrids with a single event for corn borer or for rootworm can be planted on only 80 percent of a grower's acres. Dual event hybrids will have a lower refuge requirement.

Q: Can I plant my refuge in the same field as the Bt corn?

A: Yes, EPA allows the non Bt corn refuge to be planted as strips running the length of the field. The strips need to be at least six to 12 rows wide.

Q: How is the refuge strategy for Bt corn hybrids for corn rootworm control different from the strategy for corn borer hybrids?

A: Refuge requirements are becoming more complicated as hybrids with different combinations of events become available. Be sure to understand and comply with the requirements for the hybrid(s) that you plant.

Q: I have heard the term "refuge in a bag," what is this?

A: This is the concept of planting a mixture of Bt corn hybrid seed and non Bt seed (about 5 percent). This allows the grower to comply with refuge requirements without planting or maintaining a separate refuge.

Q: Can I use "refuge in a bag" hybrid?

A: This concept is just entering the marketplace, but should become more and more available over the next few years. In general, hybrids with two or more events for both European corn borer and rootworms will be allowed to use this strategy.

Q: What can I, as a grower, do to help avoid the development of pests that are resistant to Bt corn?

A: Follow the resistance management recommendations provided by CSU Extension specialists, your seed company, and the EPA. Use good agronomic practices to avoid unneeded crop stress. Report any suspected failure

s to the seed company and to local Extension entomologists as soon as possible.

Q: How do I tell if I have a Bt corn failure?

A: Identifying resistance to Bt corn is a complicated process. A few damaged plants in a field may not be a sign that resistance has developed. For example, the occasional susceptible plant may get into a field either from the seed source or as volunteer plants. If the frequency of damaged plants seems unusually high, however, it should be reported.

Q: Are there ways to make future Bt corn hybrids less prone to resistance development?

A: Some future hybrids will have combinations of different delta endotoxin or VIP forms that should have fewer problems with resistance development. Others may have different genes that produce different toxins, such as scorpion venom. Hybrids with toxin combinations should be less likely to have problems with resistance development in pest insects.

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