

Site-Specific Management Guidelines

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Bt Corn and Insect Resistance Management: What Are They?

Summary

Transgenic corn with resistance to European corn borer (ECB) has been commercially available since 1996. Inserting a gene from the soil bacterium *Bacillus thuringiensis* (Bt) has genetically modified the corn plant to produce a protein that is toxic to moth larvae. Bt corn is valuable because it provides yield protection, reduces ear molds, and at least in some areas of the U.S., reduces the use of chemical insecticides. Grower response to transgenic corn has been positive. Over-use of Bt corn, however, could lead to ECB becoming resistant to Bt protein. In 2000, approximately 25 percent of the total corn acreage in the U.S. contained the Bt gene. Growers must practice insect resistance management (IRM) to ensure that this technology will be available to future generations of growers.

Introduction

Bt corn is a powerful management tool. However, many scientists and growers are concerned that planting too much of it may lead to the development of resistance in ECB. Many insects have developed resistance to conventional pesticides. For example, corn rootworm beetles in Nebraska have developed resistance to PennCap-M. Insects have a greater chance of developing resistance when insecticides are used frequently and at high concentrations. The risk of resistance development is high for Bt corn because the Bt toxins are expressed in high amounts throughout the growing season. To prevent the loss of this valuable management tool, IRM guidelines have been established to delay or stop the development of ECB resistance. This guide presents practical IRM recommendations for growers.

What is refuge and how much should be planted?

Refuge plants, or non-transgenic corn, are an important component of IRM. The purpose of planting a refuge is to dilute resistance genes by supplying an abundance of susceptible ECB moths that can mate with the rare resistant moths that have survived exposure to Bt corn (Figure 1). Offspring from these matings are likely to be susceptible to Bt corn.

Growers should plant at least 20 percent of their corn crop as a refuge. The percentage varies depending on the region of the country, so growers should consult with Extension specialists to

obtain local recommendations. The refuge must be planted close enough to Bt corn to encourage random mating of susceptible and resistant moths. Refuge corn should be located within one-quarter mile of Bt corn. If this is not possible, one-half mile proximity is acceptable in most cases. The one exception is in areas where ECB is frequently sprayed, where the proximity recommendation is one-quarter mile.

How should refuge be planted?

Planting a refuge is not something that can be done at the last minute. Growers should have a refuge-planting plan established prior to ordering seed. When possible, they should try to select Bt and non-Bt hybrids with

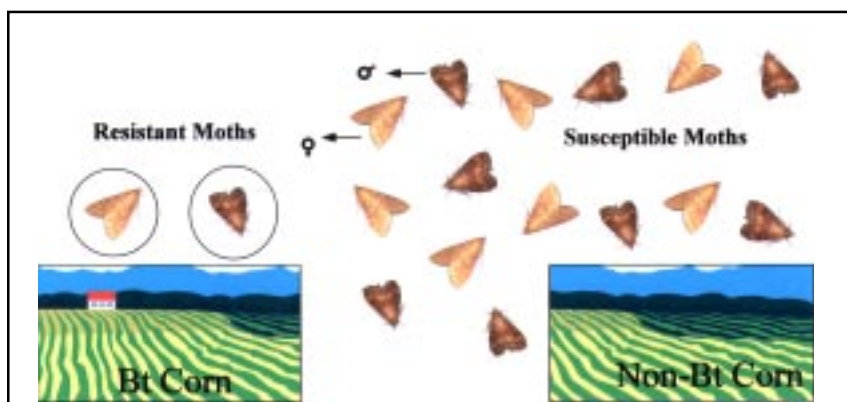


Figure 1. Refuge strategy: Reduce chances that resistant moths mate with each other by providing large numbers of susceptible moths from the refuge, non-Bt corn. Offspring of these moths are susceptible to Bt. Recommended amounts of refuge to delay resistance is 20 percent or more located within one-half mile of the Bt corn.

similar maturities and plant them at the same time. This ensures that corn types will have a similar attractiveness to ECB.

There are several factors that can influence how effective refuge is at delaying or stopping resistance. Refuge should be planted in proximity to Bt corn to encourage random mating of resistant and susceptible moths. The closer they are planted, the greater the chance that random mating will occur. However, there is a trade-off. When Bt corn and non-Bt corn occur in adjacent rows, larvae can move between the plants. This movement is undesirable because ECB larvae could start developing on non-Bt corn and move into Bt corn when they are larger and more tolerant to Bt toxins. This is not good for resistance management because these larvae could develop into resistant moths. It is important to minimize the interface between Bt and non-Bt corn. Therefore, growers should not consider alternating rows of Bt and non-Bt corn, and they should never mix seed in the planter box. Seed mixing maximizes the risk of larval movement. Other refuge-planting options have pros and cons that must be weighed by growers. They include separate fields, blocks within fields, strips within fields, and perimeter plantings (Figure 2). In addition to IRM concerns such as random mating and larval movement, growers should consider which planting option best fits their equipment and farm layout (Table 1).

Table 1. Trade-offs of refuge planting options.

	Minimizing larval movement	Encouraging random mating
Best	Separate fields	Small strips
	Large strips or blocks	Perimeter planting
	Perimeter planting	Large strips or blocks
Worst	Small strips	Separate fields

Separate Field: Planting Whole Fields of a Non-Bt Hybrid (Figure 2)

Pros: This method can minimize the need to empty seed boxes and switch hybrids. Pest management may be easier because the refuge corn is accessible and easily distinguished from the Bt corn by location. Also, refuge corn can be easily accessed for early harvest if pest pressure is high. Larval movement between Bt and refuge corn may be reduced or eliminated.

Cons: There may be less random mating of resistant and susceptible moths.

Blocks: Planting a specific block or portion of a field to a non-Bt hybrid (Figure 2)

Pros: Blocks within the field encourage random mating and minimize larval movement between Bt and refuge corn.

Cons: Block refuge may require mid-field seed box emptying and hybrid switching. Managing refuge blocks for pests may be more difficult than separate fields, but less difficult than strips. Depending on block size and how they are planted, blocks could pose some problems with accessibility for early harvest.

Strips: Planting continually alternating strips of Bt and non-Bt hybrids (Figure 2)

Pros: This method can eliminate the need to empty seed boxes and switch hybrids. If a grower has an 8- or 12-row planter, dedicating the three end row units to a non-Bt hybrid would produce 38 percent and 25 percent refuge, respectively. Strips ensure that refuge is close to the Bt corn, thereby enhancing random mating of susceptible and resistant moths.

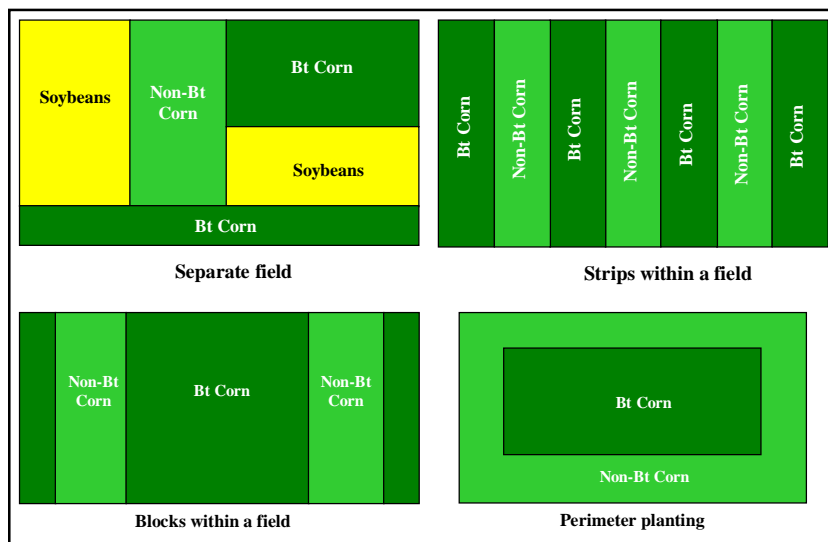


Figure 2. Examples of refuge strategies.

Cons: If a grower has a small planter, this method may not be practical. Each strip should be at least six rows wide because narrow strips may increase larval movement between Bt and non-Bt corn, which could accelerate the development of resistance. Pest management in the refuge and early harvest may be more difficult because the refuge corn is not easily distinguished from the Bt corn.

Perimeter planting: Planting a non-Bt hybrid around the perimeter of a field (Figure 2)

Pros: The refuge corn is accessible for early harvest if pest pressure is high. This type of planting will encourage random mating because the perimeter area surrounds the Bt corn. Larval movement between Bt and refuge corn may be less than the movement that occurs in strip plantings.

Cons: This method may require seed box emptying and hybrid switching.

How should pests be managed in refuge?

Growers should monitor insect infestations in refuge corn and apply insecticide only when economic thresholds are exceeded. Insecticide applications in the refuge will reduce ECB populations and the value of the refuge to IRM. Use of Bt biological insecticide should be avoided because it also can lead to the development of resistance.

Why should refuge be planted?

Growers are required to plant a non-Bt refuge when they plant Bt corn. When purchasing Bt seed, many seed companies require growers to sign a contract stating that they will plant a refuge. Regardless of whether resistance management is regulated or not, it just makes good sense. Bt is a valuable tool that can save growers time and money. Good IRM stewardship ensures this technology will be available for future generations of growers. ■

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