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Resistance Management for European Corn Borer and Bt Transgenic Corn: Refuge Design and Placement

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One of the key issues surrounding the use of Bt transgenic corn hybrids is resistance management. These corn hybrids have been engineered to produce a version of the insecticidal protein from the naturally occurring soil bacterium, *Bacillus thuringiensis* (Bt), that is toxic to European corn borers and a few other insects. Corn borer larvae feeding on Bt corn are exposed to the Bt toxin at much higher levels than from use of foliar Bt insecticides, such as Dipel or M-Peril. Also, corn borer larvae are exposed to Bt toxin for much longer periods when feeding on Bt corn. Under this high level of selection pressure, the threat of resistance necessitates the implementation of resistance management strategies to prevent or at least delay the development of resistance.

An important principle of resistance management for European corn borer and Bt corn is the use of refuge plantings. A refuge is any host plant (non-Bt corn, potatoes, oats, sorghum, and some weeds) not producing Bt proteins or not being treated with conventional Bt formulations. The purpose of the refuge is to supply a source of Bt-susceptible European corn borer that could mate with resistant European corn borer potentially emerging from nearby Bt corn. In current resistance management strategies the refuge must be non-Bt corn. As a condition of registration by the Environmental Protection Agency (EPA), industry registrants have developed resistance management plans to be implemented by producers. Specific resistance management information is a part of each corn seed bag label. Be sure and discuss resistance management with your seed dealer.

The EPA has established the following resistance management requirements.

1. On each farm, growers may plant up to 80 percent of their corn acres with Bt corn. At least 20 percent of their corn acres must be planted with non-Bt

corn and treated only as needed with insecticides. Decisions to treat the refuge must be based on economic thresholds. Conventional Bt products (liquids or granules) must not be used on the non-Bt refuge.

2. Plant non-Bt corn refuge within, adjacent to, or near the Bt cornfields. The refuge must be placed within 1/2 mile of the Bt field, preferably within 1/4 mile.
3. If refuge is established as strips within a field (*Figure 1E*), the strips should not be narrower than four rows.

Figure 1 presents some general within-field refuge configurations. *Figure 2* presents two examples of how you might establish a refuge for a Bt cornfield.

Refuge Considerations

- Linear blocks, brackets, or border refuge plantings (*Figure 1A, B, and C*) are relatively easy to plant, treat, monitor, and harvest. They have the added advantage of acting as buffer areas between the Bt corn and non-target habitat or non-GMO cornfields.
- Strips (*Figure 1E*) have the advantage of providing susceptible European corn borer to all parts of the Bt field, but they also have several drawbacks. Strips cannot be treated separately from the Bt corn. Harvest may be difficult if non-Bt strips dry down differently than the Bt corn. Also, it is difficult to keep track of where the strip rows begin or end, so monitoring is more difficult.
- Do not plant strips narrower than four rows or mix seed. This increases the risk of resistance occurring

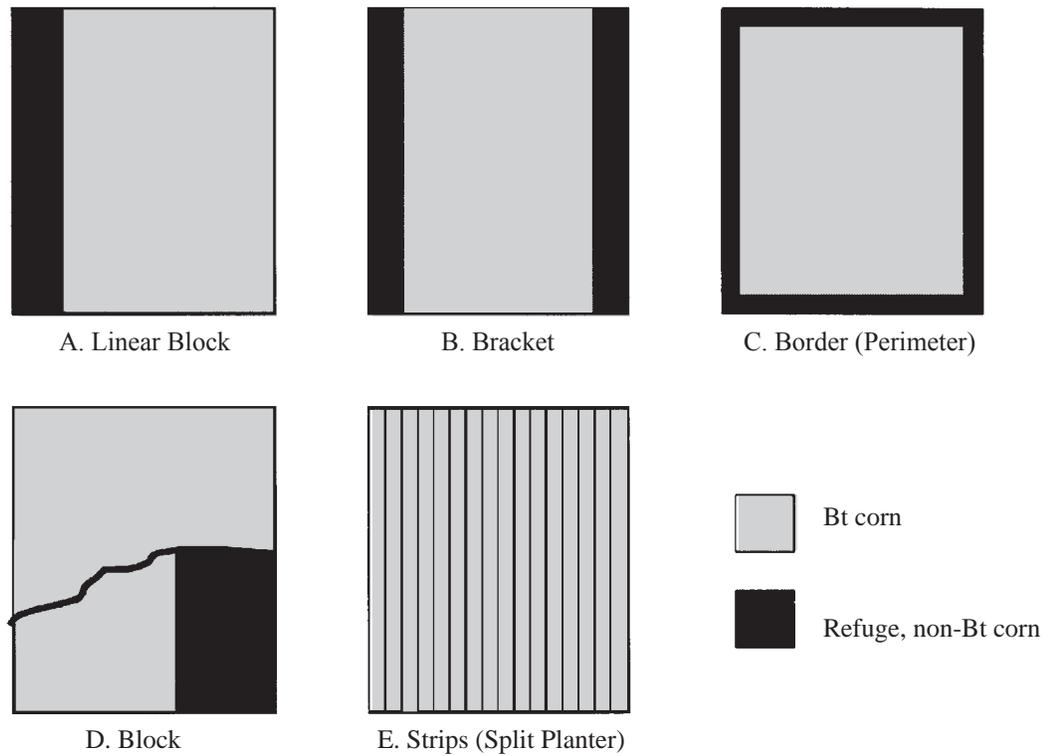


Figure 1. General types of within-field refuge configurations.

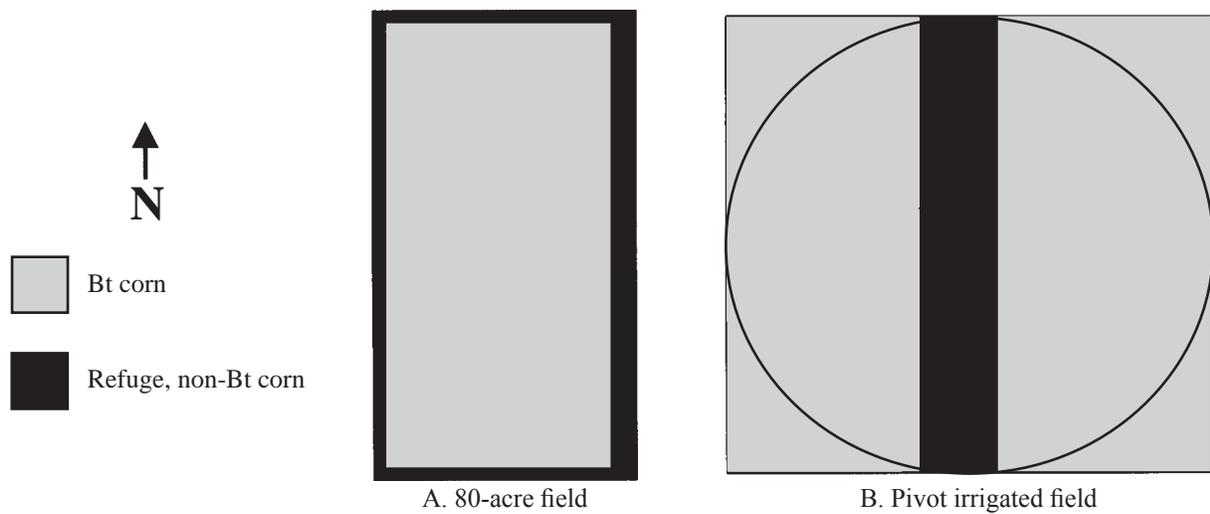


Figure 2. Examples of refuge design (30-inch row spacing, 16-row planter).

A. 80-acre field. In this field, planting non-Bt corn in 32 row end rows, 32 rows on one side (north-south), and 48 rows on the other side can attain a 20 percent refuge. This border type of refuge has the added advantage of providing a buffer around the entire field, which reduces problems associated with pollen drift.

B. 120-130 acre field under pivot irrigation. If only the pivot circle is planted to corn, then a linear block composed of 160 rows of non-Bt corn meets the 20 percent refuge requirement. If the pivot corners are planted to corn (approximately 160 acre total), increase the number to 208 rows. Although this design does not border the field, it does have the advantage of intersecting the pivot head in the center of the field. This area often is wet and weedy, providing an attractive area for European corn borer moths to aggregate and mate.

because European corn borer larvae often move from plant to plant. Corn borer larvae that can survive eating small amounts of Bt (low level resistance or tolerance) can end up on a non-Bt plant and survive.

- The design for planting strips will depend on your planter. For example, dedicating three end row units of a 12-row planter will effectively give you a 25 percent refuge with a 6-row strip size. If you have a 6-row planter you can achieve a 25 percent, 6-row refuge by splitting the planter into three units of Bt and three units of non-Bt and only strip one-half of the cornfield.
- The Bt-susceptible European corn borer from the refuge must be present at the same time as possible Bt-resistant European corn borer from the Bt cornfield. To achieve this the corn hybrid in the refuge should be agronomically similar (e.g. similar days to maturity) to the Bt hybrid, planted at the same time as the Bt field, and managed in the same manner as the Bt field. In this way the European corn borer moths will be equally attracted to the refuge and Bt cornfield. Larvae also will develop at the same rates and emerge as adults at the same time.
- Using a neighbor's cornfield as a refuge is not allowed because the hybrid selection, planting time, pest control, and other production activities are not under the control of the grower planting the Bt corn.

- Planting only non-irrigated pivot corners as refuge is not recommended because the corn plants in these areas are significantly different and less attractive to European corn borer moths than the corn under irrigation. Remember, the idea is to produce Bt-susceptible European corn borer moths.
- The closer the refuge is to the Bt field the better. This brings Bt-susceptible European corn borer in close proximity to any Bt-resistant European corn borer that may survive in the Bt cornfield. Female European corn borer generally mate close to where they emerge as adults, so having nearby refuge increases the chances that a susceptible European corn borer will mate with a resistant one.
- You can combine refuge configurations to meet the required 20 percent refuge.

A web-based, interactive refuge builder tool is available at <http://agbiosafety.unl.edu/education/refugebuilder/refugebuilder.htm>. Additional information on European corn borer management, resistance management, and Bt corn hybrids is available through your local County Extension Office. This information also is available through the UNL Entomology Department Web site located at <http://www.ianr.unl.edu/ianr/entomol/entdept.htm>

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