

Bt Refuges for Corn Borer Management

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The EPA regulates resistance management policies used by commercial corn producers when using Bt-corn seed. Initially, Bt-corn technologies required the use of a structured refuge to delay the development of pest resistance to the Bt toxins. However, some newly approved Bt-corn technologies offer other resistance management strategies. These include the standard 20% structured refuge, a reduced 5% structured refuge, and refuge in the bag (a one bag option). The elements of these are:

20% Structured refuge

- At least 20% of the corn grown on all farms must be non-Bt (the refuge for corn pests). This can be planted as strips in the Bt corn field, as a block, or as separate fields. In cotton-growing counties, the structured refuge is increased to 50%.
- The refuge be within 1/4 mile to 1/2 mile of the Bt corn if it only has traits to control corn borers, and immediately adjacent to Bt corn if it contains traits for corn rootworm control.

5% Structured refuge (for SmartStax and Intrasect technologies only)

- The structured refuge is reduced to just 5% with the SmartStax and Intrasect technologies. These can use reduced refuges because they use gene pyramiding (multiple independent toxins are used to control pests).
- The refuge be within 1/4 mile to 1/2 mile of the Bt corn if it only has traits to control corn borers (Intrasect), and immediately adjacent to Bt corn if it contains traits for corn rootworm control (SmartStax).

Refuge in the Bag (AcreMax1 and AcreMax RW only)

- With refuge in the bag (RIB), a small amount of non-Bt seed (10%) is preblended with the Bt seed. With AcreMax RW, no additional refuge is needed. With Acremax 1, a 20% structured refuge for corn borers is still needed, the AcreMax RW can serve as the corn borer refuge for AcreMax 1 fields.

Why Use a Refuge?

Using refuges with Bt corn is important and it benefits all growers directly. This article addresses the some of the key reasons why growers need to plant a corn borer

refuge when using Bt corn and discusses how the refuges should be deployed and managed.

Spread Your Risk

European and southwestern corn borer levels are highly variable from year to year. While a producer may have substantial losses to corn borers one year, that does not necessarily mean that the problem will be as bad or worse the following year. Several factors influence the likelihood of corn borer problems. These include corn borer levels in the fall, parasitism rates, overwintering survival, spring weather conditions during moth flight, and corn planting dates.

Because the Bt-corn seed is an added expense, growers want to use it where it will be economically advantageous. In years when corn borers are not a problem, there is no advantage in using Bt-corn and the added cost of the seed is not recovered. Growers who have had a history of corn borer problems can spread their risk by only planting a portion of their crop to Bt corn. This reduces seed costs across the entire farm while protecting a substantial portion of their crop from corn borers. In addition, this acreage of non-Bt corn helps to reduce the potential of ECB developing resistance to Bt-corn.

Evaluate the Need For and Return of Bt Corn

Planting the entire farm with Bt corn does not allow the grower to compare its performance to standard hybrids. The infestation level in the standard hybrids in the refuge area provide an estimate of the corn borer levels on the farm. The corn borer economic scale (see ENT-49) can be used to determine the economic loss due corn borers. This value can be compared to the premium cost of the Bt seed. The results of this comparison can be used to make future planting decisions.

Effective Resistance Management

Following the approved refuge plan for each type of Bt corn technology is the only strategy to prevent pest resistance. In the unfortunate event that corn borers did develop resistance to Bt corn, growers in that area would undoubtedly lose a tremendously valuable corn borer management tool.

While the possibility of pests developing resistance to Bt corn is only a theory, insect pests have a long history of developing resistance to any pest management tactic that

is used for a long period of time over a wide area. The examples pests being able to overcome pest management strategies are too numerous to list! Consider the western corn rootworm beetle in Illinois and Indiana. For more than 20 years it was effectively controlled through the use of a corn-soybean rotation. The eggs that were laid one summer in a corn field would hatch the following year in what has become a soybean field. This pest had been a problem only with continuous corn. But it adapted. Now a portion of the female beetles lay their eggs in soybean fields and rootworms are now a serious problem in first-year corn in this area. Don't underestimate the ability of insect pests to adapt!

Using Refuges

For refuges to effectively delay corn borer resistance, they must be designed to take advantage of a few key elements. The first element of a refuge is that if a resistant corn borer is able to develop on Bt-corn, we want to make sure that it is most likely to mate with a >normal= corn borer so that these offspring will still be susceptible to the Bt toxin. To do this, there must be a reservoir of susceptible moths around each Bt corn field. At least 20% (5% for SmartStax and Intrasect Bt corn) of the corn acreage on each farm must be non-Bt corn in order to provide a sufficient reservoir.

Another important element is timing. It is important to have the Bt and non-Bt corn in about the same stage of development throughout the season. This is because pests often select fields for egg laying based on development stages of the corn. To ensure the effectiveness of the refuge, the Bt and non-Bt corn need to be planted at about the same time and have similar maturity. It is not necessary to have a refuge each day when Bt corn is planted on consecutive planting dates. However, there should be at least one refuge for Bt corn planted over a 4 to 7 day period.

Planting Arrangements

Mixing of Bt and Non-Bt seed in Hopper Boxes: This is not approved. This results in a mixture of Bt and non-Bt corn in the same row and may favor, rather than delay the development of resistance. While this may appear to be the same as refuge in the bag technology, the Bt corn used with refuge in the bag uses multiple toxins against each pest targeted.

Planting Bt and Non-Bt Corn in Strips: Growers fill some of the hopper boxes on the planter with Bt-seed and some with non-Bt seed. This is one possible arrangement. Growers need to read the seed label to determine the minimum number of rows that can be used with this refuge arrangement.

Planting the Bt and Non-Bt Corn in Large Blocks: This is the recommended method of planting the refuge for most types of Bt corn. One portion of a large field is designated for Bt-corn and the other for the non-Bt

refuge. In this situation, insecticide sprays or early harvest can be used to minimize corn borer losses in the refuge, and the grower can manage weed control according to the needs of the particular hybrids. If Bt and non-Bt corn cannot be planted in the same field, then adjacent fields or fields within one-quarter to one-half mile of the Bt corn can be used as refuges for Bt corn using corn borer traits only and immediately adjacent for Bt corn with rootworm traits.

Managing Corn Borers in the Non-Bt Refuge

While the reason for planting a refuge is to maintain a population of Bt- susceptible pests, growers should still manage those refuges to avoid serious losses. When using a 20 percent refuge with Bt corn plantings, growers may consider spraying for corn borers or other pests if scouting indicates it is economical.

Planting Dates and the Potential for Corn Borer Losses

Extremely early or late planting will increase the potential for borer damage. The first generation can be very damaging to early plantings, while late-planted fields are prone to attack by the second. Generally, Bt corn has a greater yield advantage with later planting dates because of increased corn borer, corn earworm, fall armyworm, and black cutworm activity. It is the late-planted refuges that are most likely to be damaged by corn borers.

Early Harvest

This option can reduce corn borer losses due to broken or lodged plants or dropped ears. Second generation larvae feed primarily in the plant's ear zone and below. This damage is the primary cause of harvest loss. Early harvest of heavily-infested fields, can be an effective strategy with corn borer refuges.

Determining the Need to Spray Corn Borers in the Refuge

Careful scouting of fields is the most effective means of detecting economic infestations of the European corn borer and other pests. With the first generation in late May and early June, examine the whorl leaves of 20 consecutive plants in at least 5 areas of the field. Look at the leaves for the "window-pane" type of feeding damage caused by the larvae. Pull the whorl from one damaged plant at each stop and unroll it carefully to look for live larvae and their size. The percentage of infested plants in the field and size of the larvae present can help you determine the need for an insecticide application. Sprays should be considered if 50% of the plants show "shot hole" damage and live larvae are present in the whorl. Once larvae bore into the stalks treatment is not effective.

The same general procedure is followed with the second generation; however, the leaf axils, leaf sheaths, and ear shank areas should be examined for live larvae. Again, the percentage of infested plants and the size of larvae

are the keys to determining the need for treatment. Treatment is suggested if egg masses average one per plant and egg hatch has begun or if 50% of plants inspected have live larvae feeding on the leaves or tassels in leaf axil or behind sheaths. If your examination

indicates that half of the larvae have entered the stalk, treatment is not recommended.