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NF594

Resistance Management for YieldGard Rootworm™ *Bt* Corn

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In 2003 the U.S. Environmental Protection Agency and Monsanto announced the registration of YieldGard Rootworm™ corn containing event MON863. These hybrids express a protein in the roots from the soil bacterium *Bacillus thuringiensis* (*Bt*) that is toxic to larval corn rootworms. Do not confuse YieldGard Rootworm corn with YieldGard Corn Borer™ corn or any other *Bt* corn hybrids that are resistant to European corn borer. The YieldGard Rootworm™ corn hybrids contain a different *Bt* protein (Cry3Bb) that is toxic to corn rootworm, but has no effect on corn borers or any other caterpillars.

As with past *Bt* corn hybrids, farmers who grow YieldGard Rootworm™ corn will be required to use insect resistance management (IRM) plans. Corn rootworms have great potential to develop resistance to management practices. Nebraska corn growers should be well aware of the potential for western corn rootworms to develop resistance to insecticides. It has happened twice in Nebraska; once in the 1950s to the cyclodiene insecticides (dieldrin, aldrin, and heptachlor), and in the 1990s to methyl parathion. People in northeastern Nebraska should be aware that the northern corn rootworm extended diapause trait evolved in response to past rotational practices in the Midwest where corn-soybean rotations were used routinely for long periods. Northern corn rootworms also developed resistance to the cyclodiene insecticides in the 1950s.

Similar to past *Bt* corn resistance management plans, YieldGard Rootworm™ corn requires the use of a refuge area of non-YieldGard Rootworm™ *Bt* corn. The purpose of this planting is to provide a local source of rootworm beetles that have not been exposed to the Cry3Bb *Bt* protein. The rationale for this strategy is that beetles emerging from the refuge area would be able to cross-breed with any potentially resistant rootworms emerging from the YieldGard Rootworm™ corn field, reducing the likelihood of resistance building.

Although the IRM program is similar to those for earlier *Bt* corn that targeted European corn borer, there are some significant differences. This only makes sense, as the biology of the corn rootworm is very different than that of the European corn borer. In particular, rootworm beetles mate very soon after their emergence and before they begin to disperse; to encourage mixing of susceptible and potentially resistant beetles, the refuge must be planted closer to the YieldGard Rootworm™ corn than has been required previously for the *Bt* corn hybrids used for corn borer control.

The resistance management requirements for YieldGard Rootworm™ corn are:

- Growers must plant a structured refuge of at least 20 percent non-YieldGard Rootworm™ corn that may be treated with insecticides (e.g., seed treatments, liquid or granular insecticides) as needed to control corn rootworm larvae.
- Growers will not be permitted to apply corn rootworm labeled insecticides to the refuge for control of insect pests (either rootworm beetles or other insects, e.g., western bean cutworms, grasshoppers, etc.) while adult corn rootworm are present unless the YieldGard Rootworm ™ field is treated in a similar manner.
- Refuge planting options include blocks in or adjacent to YieldGard Rootworm™ cornfields or as in-field strips.
- External refuges must be planted adjacent to YieldGard Rootworm™ fields.
- When planting the refuge in strips across a field, refuges must be at least 6 rows wide, preferably 12 consecutive rows wide.

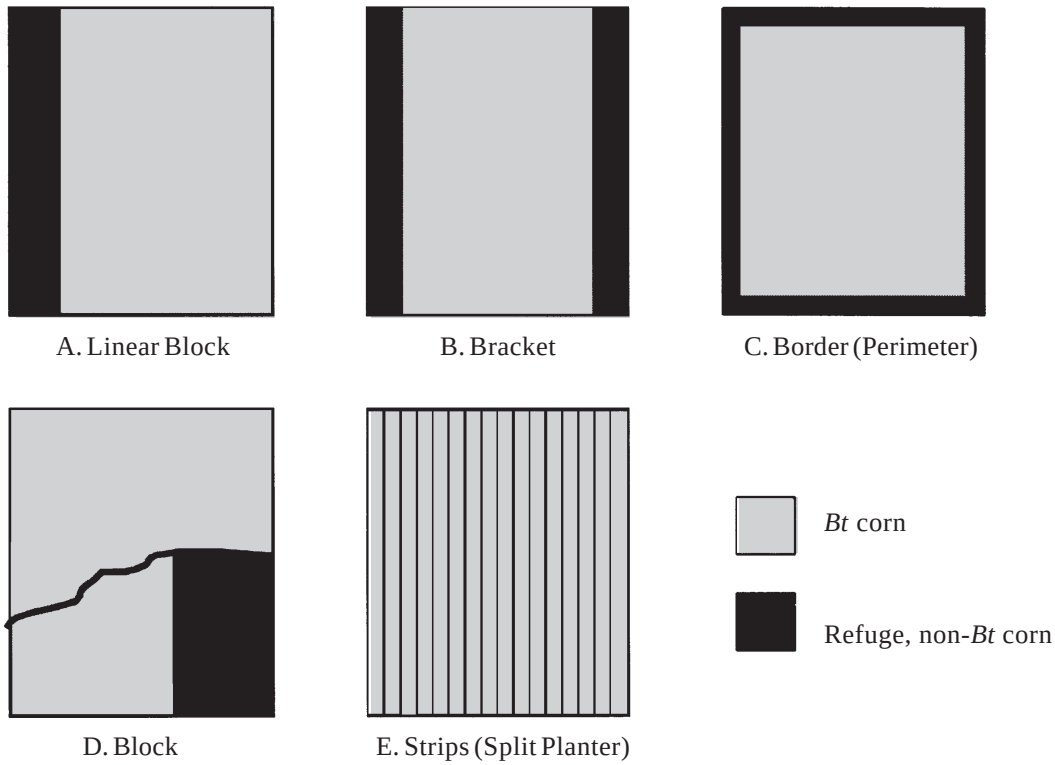

Figure 1. General types of within-field refuge configurations.

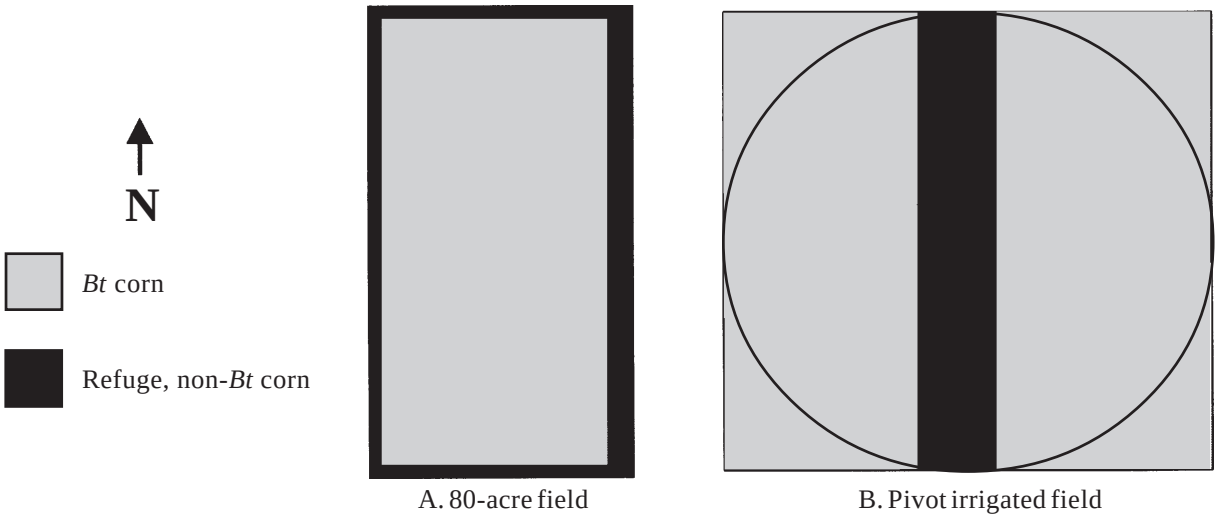

Figure 2. Examples of refuge design using a 30-inch row spacing, 16-row planter.

A. In this 80-acre 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 provide a 20 percent refuge.

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.

- In addition, the refuge must have a similar cropping history as the YieldGard Rootworm™ corn, that is, if the YieldGard Rootworm™ is planted in ground that was corn the previous year, so must the refuge. General management of the YieldGard Rootworm™ corn and the refuge should be similar, e.g., planting dates, irrigation, fertility programs, etc.

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 corn rootworms 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 may be difficult to keep track of where the strip rows begin or end, so monitoring may be more difficult.
- Do not plant strips narrower than six rows or mix seed. This practice would increase the risk of resistance occurring because corn rootworm larvae may move from plant to plant. Corn rootworm larvae that can survive eating small amounts of the *Bt* toxin (selecting for resistance) could move to 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 and maintain the 6-row strip size. If you have a 6-row planter you can achieve the 25 percent, 6-row minimum refuge by splitting the planter into three units of *Bt* corn and three units of non-*Bt* corn and only strip one-half of the cornfield.
- The *Bt*-susceptible corn rootworm beetles from the refuge must be present at the same time as possible *Bt*-resistant corn rootworm beetles from the *Bt* cornfield to accomplish the desired mixing. 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 corn rootworm larvae 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 suitable for corn rootworm survival than the corn under irrigation. Remember, the goal of the refuge is to produce enough *Bt*-susceptible corn rootworm beetles to cross breed with those emerging from the *Bt* corn.
- You can combine different refuge configurations to meet the required 20 percent refuge.

YieldGard Plus™

Starting in 2004 a *Bt* corn which possesses two different *Bt* proteins (YieldGard Plus™) will be commercially available. This hybrid has activity against both European corn borer and corn rootworm larvae. The resistance management plan can be met in two ways:

1) Plant a minimum of 20 percent of each farm's acreage to a non-*Bt* corn hybrid, within or adjacent to the YieldGard Plus™ field. In this case the same non-*Bt* corn hybrid can serve as a refuge for both European corn borer and corn rootworm. If refuges are planted in strips, they should be no less than six rows wide. All other comments above apply.

2) Alternately, two separate refuges may be planted, one meeting the European corn borer guidelines (minimum of 20 percent acres planted to a hybrid without *Bt* proteins active against European corn borer, and refuge within 0.5 mile of YieldGard Plus™ field), and a second refuge meeting the requirements for the corn rootworm refuge (minimum of 20 percent of acres planted to a non-YieldGard Rootworm™ hybrid and planted within or immediately adjacent to the YieldGard Plus™ field). The possible advantage to this approach is that a *Bt* corn active against European corn borer can serve as the refuge acres for corn rootworms (since this protein is not active against rootworms), and a YieldGard Rootworm™ hybrid could serve as a refuge for European corn borer (since this protein is not active against European corn borer). In this way, the refuge acres could be protected from one or the other of the two most important corn insects in Nebraska, without having to use planting time or post-emergence insecticides.

Producer Questions on Resistance Management

Q: I want to plant my refuge acres in the pivot corners, so I can plant the YieldGard Rootworm™ hybrid where there is the greatest yield potential. Is this OK?

A: No. The refuge acres must be treated similarly to those planted with the YieldGard Rootworm™ hybrid with respect to agronomic practices, planting date, fertility, irrigation and previous crop. All these factors may influence survival of rootworm larvae and the success of the IRM plan in delaying resistance development.

Q: My neighbor isn't going to plant YieldGard™ corn on his farm. Why can't I use his neighboring corn fields as my refuge?

A: Each grower is responsible to follow the IRM requirements for his or her farm. Your neighbor may change plans and plant soybeans where you thought corn was going to be planted. Also, the planting dates may vary greatly between your field and your neighbor's, thus decreasing its value as a refuge for your field.

Q: I buy my hybrids from more than one company. Who's going to know if I follow the IRM requirements or not?

A: EPA has required the registrant to hire inspectors who will be visiting grower fields to see that IRM requirements are being met. EPA also requires companies to report their sales data. This information can be combined for all fields in a locality to check if more than 80 percent of the corn acres were planted to YieldGard Rootworm™ corn.

Q: Why should I follow the IRM plan? If resistance does occur, the companies can just find another *Bt* toxin to add to corn.

A: When you bought the seed, you signed a contract with the company agreeing to comply with the IRM plan requirements. Failure to comply may result in the company not selling these hybrids to you in the future. Also, we don't know the characteristics of resistance that may develop in rootworms. It is possible that rootworms will develop resistance to more than one type of *Bt* toxin depending on the mechanism of resistance that develops, making it more difficult to find an effective replacement toxin. This process, called cross resistance, has occurred before in western corn rootworm with resistance to synthetic organic insecticides.

Q: I want to plant my refuge across the road from my YieldGard Rootworm™ cornfield. Is this close enough to be considered adjacent?

A: Yes, the refuge can be separated from the YieldGard field by a road or ditch, but not another field.

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C-14, Field Crops
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