Corn Rootworms in Wisconsin: A Brief Overview of Bt Resistance and Management

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Introduction to Bt Corn Rootworm (CRW) Resistance

Reliance on a single pest management tactic will, in time, lead to resistance. Using Bt CRW hybrids to control corn rootworms has been a common, if not singular, management tactic. As a result, resistance to the Bt CRW hybrids occurred relatively soon after commercial sale in 2003. Other contributing factors include:

1) Expression of the Bt CRW proteins is considered a moderate dose compared to the high dose technology of the above ground Bt traits
2) Only 4 unique Bt proteins are available to control corn rootworms. 3 of the 4 are structurally similar and have cross resistance concerns.
3) Resistance is a dominant trait
4) There are no "fitness costs" to the resistant individuals. Meaning the resistant rootworms are as healthy, lay as many eggs, live as long, etc as their susceptible counterparts.

To be clear, the use of Bt hybrids can still be a viable tactic but only if the level of resistance is low within a field and future management plans are adapted accordingly. To maintain effectiveness of the Bt CRW hybrids, alternative management practices should be used in a diversified approach to reduce the selection pressure on the Bt CRW hybrids.

Life Cycle

Both the northern and western corn rootworms are present in Wisconsin and have similar life cycles. Rootworms overwinter as eggs laid in the soil of corn fields. These eggs hatch in early June of the following year and the larvae will feed exclusively on corn roots. Adults begin emerging late June and prefer to feed on corn silk and pollen. They will not begin laying eggs until early to Mid-August. Female northern and western corn rootworms will lay an average of 300-400 eggs, respectively. Egg laying is completed by early September.

Northern (l) and Western (r) corn rootworm adults

Field Scouting

Monitoring adult beetles during the egg laying period is a key component for managing rootworms. Rootworm populations vary from year to year and field to field. Counting beetles during the egg laying period will provide information about the potential for damage the following year. Allowing for a proactive management approach that can be used to select the appropriate management practices on a field-to-field basis.

The following educational resources developed by the University of Wisconsin Division of Extension are available to help learn the correct technique, timing and threshold required to successfully scout for adult beetles.

Field Scouting for Corn Rootworm

Corn Rootworms: How to Scout for Corn Rootworms (video)

Monitoring Corn Roots for Damage

The benefits of monitoring corn roots for damage are two-fold. First, it provides early insight regarding the level of Bt resistance that may already be present in a field. This background information will allow you to choose a Bt protein rotation to delay resistance and ensure effective control. Monitoring roots for damage will also provide confidence that your selected management practice is providing the level of protection needed.

Larval damage

Do not assume lodged corn is a result of rootworm feeding. Many factors including diseases, soil compaction, high winds, etc. may also cause plants to lodge. Conversely, do not assume that straight standing corn does not have rootworm feeding. To understand the current level of damage you must dig and

wash roots. Below are resources developed by the University of Wisconsin Division of Extension to help with identifying damage, proper timing and rating procedure.

Corn Rootworm: How to validate your management decision (video)

Evaluating Corn Roots for Rootworm Damage

Corn Rootworm Management Practices

To maintain effectiveness of the Bt CRW hybrids and avoid resistance, other management practices should be used to control corn rootworms. Several management practices are available and understanding their management niche will lead to effective and economical use. Your corn rootworm management goal should be to use a variety of management practices in a coordinated effort that is based on field scouting data and root monitoring efforts.

Crop Rotation

Crop rotation is the best management practice and will control all levels of potential rootworm damage. Typically, females will lay eggs in corn fields and the larvae, which can only feed on corn roots, will emerge the following year and starve if corn is not present. However, two possible exceptions are noted below.

Exception #1. Corn rootworms have a history of developing resistance to several management practices and this list includes rotation. In areas of the Midwest that have had a long history of using a corn/soybean rotation, western corn rootworms have adapted by laying eggs in soybean. These eggs hatch the following year in corn. This situation was first reported in the mid-1980's in Illinois and Indiana and not reported until 2002 in southeastern Wisconsin. Despite a few years of damage to some first-year corn fields in southern Wisconsin, this scenario has not been a problem for more than a decade.

Exception #2. The northern corn rootworm has its own unique adaptation to a corn/soybean rotation. This species has, over time, selected for a trait that requires two winter chill periods before eggs will hatch. This adaptation, called extended diapause, has been a problem in Minnesota, Iowa, and South Dakota and Nebraska. It has not been reported in Wisconsin.

You may understandably have a concern about the effectiveness of rotation if you grow corn in Southern or Northwestern Wisconsin. To gain confidence in this practice please consider digging first-year corn roots in late July or August to look for signs of feeding injury in first year corn.

Neonicotinoid Seed Treatments

Widespread use of neonicotinoid seed treatments began with the release of the bioengineered corn hybrids targeting secondary insects like white grubs and wireworms. However, the highest labeled rate will control low to moderate populations of rootworms.

Corn rootworm populations were at historic lows during the 2017-2019 growing seasons. Although populations were higher in 2020, they are still considered relatively low. Therefore, these seed treatments are a viable management option if you have scouting data to identify those fields which are at or slight above the beetle scouting threshold of 0.75 beetles/plant.

There are risks to pollinators if using neonicotinoid seed treatments. Dust from planting operations may contain trace amounts of these seed treatments. Acute poisoning can occur if particle drift is allowed to move onto hives or onto pollen and nectar sources.

Soil Applied Insecticides on non-Bt CRW Hybrids.

Prior to EPA approval of Bt CRW hybrids in 2003, soil insecticides applied at planting were successfully used as the primary management tactic on continuous corn. University of Wisconsin field research continues to confirm that selected insecticides are still effective even under high feeding pressure. Therefore, using soil insecticides on non-Bt hybrids can be a good alternative to Bt hybrids. However, soil insecticides will vary in their efficacy. Reading product labels can provide insight regarding their control niche. If the label suggests *"In areas where large rootworm populations are present, a multi-approach system (high seed treatment rate, Bt hybrid) may be needed for optimum control…."* consider using a different insecticide for those fields with high pressure. Using a soil applied insecticide plus another control option increases production costs and selection pressure.

Rotating soil applied insecticides and/or modes of action, is important. Currently, there are 2 modes of action available for control. Because of the rootworm's past ability to become resistance to several management practices, rotating insecticide modes of action is suggested.

Calibration is important and settings on the granular insecticide's label should be used as a starting reference only. There may also be restrictions for pounds of product/acre on row spacings narrower

than 30 inches. Reading label restrictions is also important because some insecticides may have use restrictions that include placement, set back restrictions and/or implementation of buffer strips near aquatic habitat.

Bt CRW Hybrids

If your plans include using Bt CRW hybrids, plan to monitor roots for damage each growing season. This information is critical for detecting early stages of resistance and will allow for integration of other practices before damage is widespread.

Bt CRW hybrids fit well into an Integrated Pest Management (IPM) approach because you can scout for beetles and determine the damage potential prior to purchasing corn hybrids. This allows field specific recommendations that incorporate rotation, seed treatments, soil applied insecticides with non-Bt CRW hybrids along with Bt CRW hybrids. Consider using Bt CRW hybrids or soil applied insecticides in fields with the highest damage potential if you are unable to rotate.

Rotation of Bt proteins is an important management practice to prolong their viability. It was previously mentioned that there are 4 Bt CRW proteins available for use today. However, Yieldgard Rootworm (Cry3Bb1), Agrisure RW (mCry3A) and Duracade (mCry3A+eCry3.1Ab) are structurally similar and cross resistance among those 3 have been detected. To date, cross resistance has not been detected to the fourth Bt protein (Herculex RW, Cry34/35Ab1). Do not use the same or similar Bt protein within a field for more than two years in a row. Annual rotation is preferred.

The Bt CRW proteins are incorporated into several different trait families and it can be difficult to know which proteins are used in each trait family. Furthermore, switching seed companies does not mean you are rotating Bt proteins just because they market a trait family with a different name. Take a deeper look beyond the trait name listed on the hybrid and identify the Bt protein included in the product. Get help from your seed dealer or consult the Handy Bt Trait Table. This publication is updated annually by entomologists at Michigan State and Texas A&M universities.

Other Management Practices

Other rootworm management practices have been used in areas where Bt resistance has been detected. They are rarely advisable unless rootworm pressure is **extremely high**.

Layering: Using a soil applied insecticide along with a Bt CRW hybrid should only be considered if rootworm populations are so high that either practice used by itself would be overwhelmed. The rationale for this practice has been that under typical rootworm populations the addition of the soil applied insecticide is needed because lodging was previously noted in the Bt CRW hybrid. This suggests the beginning of resistance to that Bt protein(s). If that is the situation, use an effective soil applied insecticide on a non-Bt hybrid. Effective control should be expected from the soil applied insecticide *(assuming there are no label restrictions for high or "large" rootworm population densities as previously discussed*).

Adult control: Another occasionally used practice has been to apply a foliar insecticide during the egg laying period to kill beetles and reduce the damage potential during the following growing season. Similarly, this approach would only be advisable if rootworm populations are so high that any control tactic used the following growing season would be overwhelmed.

Resources available

Managing corn rootworm and Bt resistance can be complex. Please consider contacting your local UW Division of Extension County Agent/Educator if you have questions.