E1852

INTEGRATED PEST MANAGEMENT of Corn Rootworms in NORTH DAKOTA

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The northern corn rootworm (*Diabrotica barberi* Smith & Lawrence) and the western corn rootworm (*Diabrotica virgifera virgifera* LeConte) are major economic pests of corn (*Zea mays* L.) in North Dakota and in most U.S. corn-producing states. Corn rootworms cost U.S. producers about $1 billion annually in yield losses and input costs to control them.

In North Dakota, corn rootworms are most problematic in the southeastern part of the state, where most of the corn acreage is grown. However, northern corn rootworms are more abundant in areas farther northward in the state than western corn rootworms.

Both species have similar life cycles, and they typically have one generation per year. Corn rootworm biology is closely tied to that of corn, its primary host plant. Larvae feed below ground on corn root systems, whereas adults feed on foliage, silks, pollen and immature kernels. Larval root-feeding injury results in the most significant plant injury and associated yield losses caused by corn rootworms.

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Identification

Northern and western corn rootworms belong to the order Coleoptera (beetles) and the family Chrysomelidae. Like all Coleopterans, rootworm species go through four life stages: egg, larva, pupa and adult.

Eggs - Eggs (Figure 1) are oval, white to cream and approximately 1/50 inch (0.5 millimeter [mm]) long. They are extremely difficult to find without magnification.

Larvae - Larvae (Figure 2) of both species are slender and white to cream with a brown head capsule and brown anal plate at the posterior end. They pass through three instars of development. Newly hatched (neonate) larvae are slightly more translucent white than later, more solid cream-colored second and third instars. The full-grown third-instar larva is about 1/2 inch (13 mm) long.

Pupae - The pupa (Figure 3) is translucent white to cream, and is similar in size and shape to the adult; however, it lacks fully developed legs and wings. The pupa is a resting and nonfeeding stage.

Adults - Adult corn rootworm beetles can easily be identified in the field. Northern corn rootworm adults (Figure 4) are tan to pale green, 1/4 inch (5.6 mm) long beetles. Western corn rootworm adults (Figure 5AB) are yellow to yellowish-green and black beetles. Most female western corn rootworm beetles (Figure 5A) have three longitudinal stripes on their forewings. In contrast, the forewings of most male western corn rootworm beetles (Figure 5B) have a nearly solid black marking. Western corn rootworm adults vary from 3/16 inch (4.2 mm) to 5/16 inch (6.8 mm) long. Female beetles of both species are usually slightly larger than males, and female abdomens become enlarged when carrying eggs inside.

Figure 4. Northern corn rootworm adult.

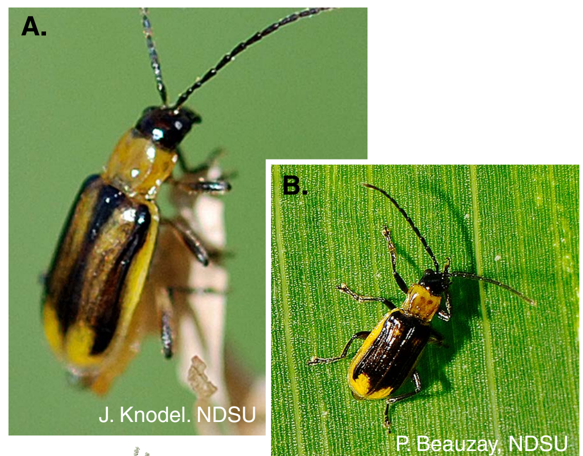

Figure 5.
A. Female western corn rootworm adult. B. Male western corn rootworm adult.

Figure 1. Corn rootworm eggs with close-up of a single egg.

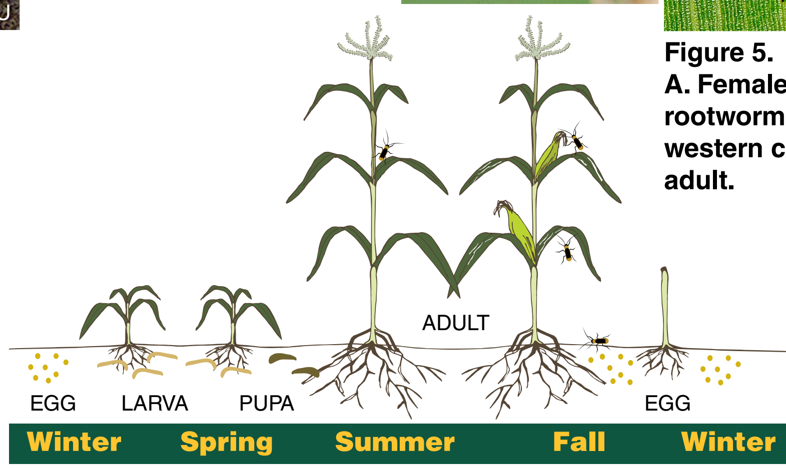

Figure 2. Corn rootworm larva.

Figure 3. Corn rootworm pupa.

Life Cycle

Northern and western corn rootworms typically produce one generation per year. Although corn is the preferred host of northern and western corn rootworms, weeds such as volunteer corn in other crops and foxtail grasses can also be attractive to egg-laying females and can serve as alternate hosts for larvae.

Corn rootworm adults usually begin emerging in mid-July in North Dakota. Northern corn rootworm beetles usually emerge first; western corn rootworm beetles emerge one to two weeks later. In North Dakota, 50 percent of adult emergence occurs by late August to early September, and it typically is completed by mid-October.

Male beetles of both species emerge about five to seven days earlier than females. Female northern corn rootworm beetles mate within one to two days after emerging, whereas most western corn rootworm females mate within 24 hours after emergence.

Females feed for about two weeks after mating, after which they are ready to lay eggs. Most egg laying occurs from late July through September. A single northern corn rootworm female can lay more than 1,000 eggs during the growing season, whereas western corn rootworm females are capable of producing more than 1,800 eggs.

Females lay eggs within the upper 8 inches (20 centimeters [cm]) of the soil surface. Some eggs will fail to survive due to several mortality factors, including predation, soil factors, extreme cold temperatures and excessive rainfall. Before eggs will hatch, they must undergo a long period in diapause, a slowed physiological state that allows them to overwinter. Eggs overwinter in the soil from September to June of the following year.

After overwintering, eggs hatch into larvae from late May through June in North Dakota. Soon after hatching, the tiny first-instar larvae orient to volatiles emitted from growing corn roots to find their host plants and begin feeding.

Larvae continue to feed as they develop, and reach maturity in the third instar. Mature third instars subsequently enter the pupal stage. Full-grown (third-instar) larvae pupate in earthen cells in the soil during early July. The transformation from pupa to adult takes about one week, with beetle emergence from soil beginning in mid-July.

Variation in the timing of egg hatch and developmental rates can result in overlaps of different corn rootworm life stages within a field.

Crop Injury

The most significant corn rootworm injury to corn occurs when larvae feed on the root system (Figure 6). First-instar larvae usually feed on root hairs and outer root tissue. Second instars feed on lateral roots and sometimes burrow into the roots. Mature third instars cause the most damage by feeding on lateral roots and often burrowing into the roots, often making longitudinal tunnels through the central core of the brace roots.

Tunneling injury can result in completely severed individual roots. Feeding scars and the remaining tissues from severed roots (Figure 7) turn brown shortly after the injury. Injured root systems, especially those in which brace roots are heavily injured and/or severed, have reduced capacity to take up water and nutrients from soil.

Figure 6. Corn rootworm larval feeding.

Figure 7. Corn root injury by corn rootworm larvae.

Severe larval root feeding injury can cause up to 50 percent yield losses. Severe corn rootworm feeding injury to roots also can cause plants to become weak and exhibit symptoms of water stress.

Severe injury to brace roots can cause plants to lodge (Figure 8). Lodging is often followed by "goose-necking," which is a curved or bent-appearing stalk condition that results from plants attempting return to a vertical orientation after lodging (Figure 9). Larval feeding injury can also predispose roots to plant pathogen infections, which can further reduce overall plant health.

Extensive plant lodging within a field can make harvesting difficult, resulting in additional losses. It should be noted that lodging can also be caused by other factors, such as severe winds, especially after a rainfall event, or feeding injury from other root-feeding insect pests. This underscores the importance of scouting for corn rootworm presence in fields exhibiting lodging symptoms.

Larval feeding injury can also predispose roots to plant pathogen infections, which can reduce overall plant health further.

Adults of both species will feed on corn leaves (Figure 10), silks (Figure 11), tassel/pollen (Figure 12), and kernels (Figure 13).

Corn rootworm beetle feeding on leaves results in feeding scars (Figure 14) that can appear as scratch marks on the leaf surface or holes (Figure 10), or leaves can be completely stripped. High corn rootworm beetle infestations can cause additional yield losses by damaging corn silks, which interferes with pollination, and by directly feeding on developing kernels.

Figure 8. Corn plant lodging near Page, N.D.

Figure 9. Lodged corn stalk showing goose-necking symptom.

Figure 10. Adult corn rootworm feeding injury to leaf.

Figure 11. Northern corn rootworm adults feeding on corn silks.

Figure 12. Northern corn rootworm adults feeding on corn tassel/pollen.

Figure 13. Northern corn rootworm adult feeding on corn kernels.

Figure 14. Corn rootworm beetle feeding scars on corn plant leaf.

Monitoring and Thresholds

Monitoring for corn rootworm adults on above-ground tissues and larval feeding injury to roots, and the use of economic thresholds are important steps of the pest management decision-making process. Monitoring can reveal whether economically threatening populations are present and help determine which pest management strategy will most effectively minimize potential yield loss.

Sampling for corn rootworm larvae is mostly recommended for fields that have a history of damaging populations. Sampling for larvae also can be used to verify the success or failure of insecticide applications or rootworm-active transgenic corn hybrids, such as those expressing Bt (*Bacillus thuringiensis*) proteins.

Larval Sampling

Soil Cube Sampling for Larvae

Sampling for rootworm larvae can be done by using the soil cube technique. In North Dakota, this should be done between mid-June and mid-July. That is when most larvae will be second or third instars, which are much easier to see than first instars.

Soil cube sampling involves the following steps:

1. Randomly select one plant from each of 10 representative areas within the field.
2. Use a knife to cut the plant stalk off at about 12 inches (30 cm) above the ground.
3. Use a shovel or spade to cut a 7-inch (18 cm) soil cube around the base of the plant, leaving the plant at the center of the cube; make sure the shovel blade is inserted vertically into the soil to avoid cutting roots.
4. Place an individual root and its associated soil cube on a 2- to 3-foot (0.6 to 0.9 meter [m]) square sheet of dark-colored plastic, cloth or tarp. The dark background makes light-colored corn rootworm larvae easier to see.
5. Separate soil from roots slowly and carefully inspect it for rootworm larvae.
6. Repeat the process for all samples, counting all larvae present, and calculate the average number of larvae per plant.

Threshold: Postemergence management of corn rootworm adults is recommended if the field **averages two or more corn rootworm larvae per plant.**

Adult (Beetle) Sampling

Before and During Pollination – Visual Adult Counts to Protect Corn Pollination

Adult Counts in Silk Masses – Begin field monitoring for corn rootworm adults a few days before the silking stage. Monitor corn plants by walking down corn rows and searching for adult beetles on the corn ear.

Adults are most active during midmorning or late afternoon, so scouting within these time periods is preferable. If no adults are found, then no further scouting is needed for three days. Continue to scout the field twice per week until pollination occurs.

If rootworm beetles are detected in the field, randomly select five nonconsecutive plants in five to 10 different locations throughout the field. Count and record the number of rootworm adults while keeping track of the number of plants sampled, and then calculate the average number of beetles per plant.

Threshold: If the field averages **five or more beetles per plant** during the first week of pollen shed, control with a foliar-applied insecticide is recommended to reduce pollination problems.

Assessing Silk Clipping – During pollen shed, randomly select five nonconsecutive plants from five to 10 representative locations within the field, and measure the length of the remaining silk that is protruding from the ear on each selected plant.

Threshold: If silks are clipped to **within 1/2 inch (1.3 cm) of the ear tip on 25 to 50 percent of the total number of sampled plants**, then control is recommended to prevent further silk damage. Yield is not affected if silk is clipped after pollination (brown silks); therefore, control will not be necessary.

After Corn Pollination – Visual Adult Counts to Determine Risk of Damaging Larval Infestations for Next Year

The potential for economic damage by corn rootworm larvae for the following year can be estimated by determining the average number of adults present on corn plants. Start scouting three weeks after pollination and continue once per week until silks are dry and brown.

Randomly select five or 10 nonconsecutive plants in 10 representative locations throughout the field for a total of 50 or 100 plants. Avoid selecting plants within 100 feet (30 m) of field edge. During corn ear inspection, carefully cover the silk with one of your hands, and then count the number of adults present by slowly allowing your hand to open. Gently disturb silks near the ear tip to dislodge and force beetles to exit.

Also check the plant stalk, upper and lower leaves, leaf axils and tassel for corn rootworm beetles. Pull leaves down when inspecting the leaf axils because adults often hide inside them. Count and record the number of adults of each species, and then estimate the average number of adults per plant by species.

Threshold for first-year corn or rotated corn: Management in the following year's corn crop is recommended if counts average **4.5 or more adults per plant for either northern corn rootworm or western corn rootworm or any combination of the two species.**

Threshold for continuous corn: Management in the following year's corn is recommended if a field averages **0.75 or more adults per plant for either northern corn rootworm or western corn rootworm or any combination of the two species**.

Monitoring Adults With Traps

Corn rootworm adults can be monitored using sticky traps. During early August, deploy 12 unbaited Pherocon AM® yellow sticky traps per 10 to 50 acres of corn. Traps should be arranged into two linear transects separated by at least 330 feet (100 m). The transects also should be at least 100 feet (30 m) away from field edges and/or waterways. Each transect should contain six sticky traps that are at least 165 feet (50 m) apart from each other.

Each trap should be attached to a corn plant stalk at ear height (Figure 15). Replace traps once per week for four to six weeks, or until the threshold is reached. Count and record the number of beetles caught on each trap.

Lastly, calculate the average number of beetles per trap per day (add total number of beetles captured from all traps and divide by total number of sticky traps, then divide that result by the total number of days traps were deployed in the field).

Threshold: A capture rate of **two or more beetles (either species or any combination of the two species) per trap per day during the week of peak abundance** indicates that a high corn rootworm population is expected the following year. As such, a corn rootworm management tool likely will be necessary to protect the following year's corn crop.

Figure 15. Sticky trap mounted on corn stalk at ear height to monitor corn rootworm adults (in circles).

Larval Root Feeding Injury Ratings

Quantifying rootworm larval feeding injury to corn roots can be helpful for verifying the success or failure of a soil insecticide or Bt corn hybrid, and it also can help determine the best pest management strategy for a field in the subsequent year.

To estimate the extent of larval feeding injury in a corn field, randomly select 10 plants throughout the field and excavate their roots in late August or early September. Most corn rootworm adults will have emerged by this time, so root feeding injury should mostly be completed.

Selecting plants that have been treated with the same management tool(s) is important. For example, in a field planted with Bt corn and its required refuge (non-Bt corn) in a block or strip near the field, select 10 plants from the Bt corn area and 10 plants from the non-Bt corn. Be careful not to mix plants from areas that received different management tools.

Dig roots from soil, taking care to avoid damaging them with the shovel. Soak roots in a bucket of water for 30 to 60 minutes, and then wash the soil from them. Make sure to avoid causing mechanical damage to roots during washing.

Once roots are cleaned, quantify larval feeding injury by using the Iowa State 0-3 node-injury scale (Table 1). Calculate the average root injury rating and assess it according to thresholds. One node pruned generally equates to a 15 to 18 percent yield loss.

Threshold:

Average Root Ratings	Integrated Pest Management Decision
<0.25	Bt corn hybrid is effective and protects against economic yield loss
0.25 - 0.75	Possible economic loss may depend on other plant stresses as well
>0.75	Potential economic yield loss can occur; the current management strategy is not effective and should be improved next year

Corn rootworms may be resistant to Bt protein:

>1.00	In Bt corn hybrids expressing a single toxin protein
>0.50	In pyramided Bt corn hybrids

Figure 16. A. Healthy root with minimal corn rootworm feeding injury. B. Root injured by corn rootworm larvae.

Table 1. Node-injury scale to quantify corn rootworm larval feeding injury.

Injury score	Description of the injury level to corn root system
0.00	No damage
1.00	One complete node or equivalent of one node consumed
2.00	Two complete nodes consumed
3.00	Three or more nodes consumed

A single root (for example, brace root) is counted as consumed if it is pruned back to within 1.5 inches (38 mm) of the stalk. Feeding between nodes is scored as the percentage of the complete node consumed; for example, 1.50 is equivalent to 1½ nodes consumed (Oleson et al., 2005). An uninjured corn root is shown in Figure 16A, and it can be contrasted with the root in Figure 16B that sustained severe corn rootworm larval feeding injury (rating of about 1.8). To view an interactive version of the node-injury scoring system, follow the internet link by VanDyk (2005) in the Selected References section.

Integrated Pest Management Strategies

Once a rootworm problem field is confirmed, the decision on an appropriate management strategy will depend on field history, species composition of the infestation, the presence/absence of localized resistance problems, and both financial and agronomic constraints. The benefits and limitations of various IPM strategies are discussed below.

Natural Control

Beneficial insects and related organisms that prey on or parasitize corn rootworm eggs, larvae or pupae include ground beetles, rove beetles, ants, mites, spiders and centipedes. Spiders are capable of preying on adult corn rootworm beetles. These beneficial organisims are generally not effective in reducing rootworm populations below damaging levels. However, preserving beneficial organisms can enhance the impact of other tactics.

Cultural Control

- **Crop rotation**

  Crop rotation is the No. 1 strategy for managing corn rootworm populations because it disrupts the year-to-year availability of corn, their primary host plant. Crop rotation also can help slow the development of resistance to other control tactics.

  NDSU Extension encourages crop rotation with nonhost crops, such as soybean, flax, sunflower, or wheat. Corn rootworms mainly depend on corn as a food plant, and larvae usually will starve to death on all but a few noncorn plants. As such, crop rotation with nonhost crops can effectively break the link of the corn rootworm life cycle.

  – **Adaptations of Corn Rootworms to Crop Rotation**

    Northern and western rootworm populations have adapted to crop rotation systems; however, each has adapted by a different mechanism.

    The northern corn rootworm has adapted to crop rotation through extended egg diapause (the dormant period), in which some eggs remain in diapause for two or more winters. If corn is rotated annually with soybeans or another nonhost crop, extended-diapause eggs will hatch in the subsequent spring when corn is planted again in the field.

    Northern corn rootworm populations with extended egg diapause occur in Minnesota, South Dakota, Iowa, Wisconsin and Nebraska. However, this adaptation has not been researched in North Dakota.

    Some western corn rootworm populations have shown a behavioral shift, in which variant females in regions with intensive, near universal use of a corn/soybean rotation will lay eggs in soybean fields as well as corn fields. The eggs laid in soybean fields then hatch during the following growing season when the rotation returns to corn.

    The behavioral shift by these western corn rootworm-variant females has been observed in Illinois, Indiana, Michigan and Ohio. Soybean-variant western corn rootworm populations have not been reported in North Dakota to date.

- **Control of Volunteer Corn**

  Volunteer corn or other grassy weeds growing in other rotational field crops such as soybean can be attractive to localized corn rootworm beetle infestations for egg laying or feeding on silks, leaves, or pollen. Females from North Dakota corn rootworm populations most likely will not lay eggs in fields without corn.

- **Planting Date Modification**

  Early planted corn typically produces more vigorous root systems and higher yields. However, early planted corn can also result in early silk development and pollination and, in turn, allow these processes to occur before peak corn rootworm adult emergence. This can minimize the risk or extent of silk clipping and pollination interference by beetles.

  In contrast, late-planted corn leads to later corn silk development and pollination, thus placing such fields at higher risk of significant silk clipping and kernel feeding injury. Late-planted fields also will be more attractive for egg laying by corn rootworm beetles, and therefore can be at increased risk of larval feeding injury during the subsequent growing season.

Corn Hybrid Selection

Corn rootworm management can be achieved using transgenic (genetically modified) Bt corn, which has been modified to express a variety of crystalline (Cry) protein(s) derived from the bacterium *Bacillus thuringiensis*. Specific Cry proteins have been engineered into Bt corn hybrids because of their ability to selectively kill corn rootworm larvae that feed on roots of Bt hybrids. Recently, the first new Bt corn hybrid with RNA interference (RNAi) technology has been engineered for optimal control of corn rootworms.

Bt Corn Hybrids with Cry Proteins

A Bt corn hybrid may express a single Cry protein or combination of multiple proteins, and can be engineered to target a single insect pest group (rootworm species) or multiple insect pests (corn rootworms and larvae of Lepidopteran insect pests, such as European corn borer). Bt corn hybrids expressing a single protein, such as Cry3Bb1, mCry3A or Cry34/35Ab1, are specific to and kill only corn rootworms.

A Bt hybrid with two or more proteins targeting the same insect group, such as those expressing Cry3Bb1 plus Cry34/35Ab1 or mCry3A plus eCry3.1Ab, is called a "pyramid" because all of these proteins are specifically toxic to corn rootworms.

When a Bt corn hybrid contains two different protein types targeting separate insect pest groups, the hybrid is referred to as "stacked." A Bt corn hybrid containing multiple rootworm-active Cry proteins and also protein(s) targeting other pests (e.g., larvae of Lepidopteran insect pests), or vice versa, is called a "stacked pyramid." Bt corn hybrids also can be stacked with an herbicide-tolerant trait.

Bt Corn Hybrids with RNAi technology

New Bt corn hybrid, SmartStax with RNAi technology for pest control named **SmartStax® Pro,** is currently available for corn growers. Most importantly, the SmartStax® Pro corn hybrid can be helpful in corn areas where rootworms have developed resistance to Bt corn hybrids expressing Cry proteins.

SmartStax® Pro contains three different modes of action (each one specific to kill corn rootworms): two of the Cry proteins (Cry3Bb1 and Cry34/35Ab1) and one novel RNAi-based trait *(DvSnf7)*, which targets a specific RNA sequence of western corn rootworm and uses double-stranded RNA (dsRNA). When corn rootworm larvae feed on and ingest these plants producing dsRNA, the RNAi of western and northern corn rootworms specifically recognizes and stops the production of *DvSnf7* protein. This protein is essential for corn rootworm survival, and its deactivation results in larval mortality.

Federal law protects this product and requires its use according to the label instructions. When using SmartStax® Pro and a failure of insect resistance management occurs, such as not planting the required corn refuge, growers may lose access to the license for purchasing Bt corn hybrids.

Bt Corn Requires Implementation of Insect Resistance Management

When planting a Bt corn hybrid, always follow the included instructions for planting refuge corn in the correct location and follow the area percentage requirements. Refuge seed will lack expression of the Bt protein that is used to control the target pest(s).

Some Bt corn hybrids are packaged as "refuge in the bag" (RIB) products, meaning the bag contains a mixture of non-Bt and Bt corn seeds in the proper ratio. If refuge seeds are not included in the bag, refuge seed must be planted adjacent to or within the rootworm-active Bt corn field. **Planting non-Bt refuge is extremely important because it can help delay corn rootworm resistance to Bt corn hybrids, thus extending the durability of this technology as a corn rootworm management tool.**

If a Bt hybrid is used and unexpected corn rootworm populations or severe root injury occurs in a Bt corn field, contact the associated seed company and also NDSU Extension Entomology.

For guidance in selecting a suitable Bt corn hybrid, consult the "Handy Bt Trait Table for U.S. Corn Production" in the corn section of the "North Dakota Field Crop Insect Management Guide" (NDSU Extension publication E1143-22). A web link to this publication is included in the Selected References section of this document.

How to Prevent Bt Resistance Development in Corn Rootworms

Western corn rootworm populations already have developed resistance to several Bt proteins, including Cry3Bb1, mCry3A, eCry3.1Ab and Cry34/35Ab1 in different Midwestern states. Recently, in North Dakota 2019, western corn rootworm resistance to Cry3Bb1 was found at Ransom. Also, resistance in northern corn rootworm populations to Cry3Bb1 (at Arthur) and Cry34/35Ab1 (at Arthur, Page, Ransom and Sargent) also has been reported in southeastern North Dakota.

The following strategies are recommended to reduce the risk of corn rootworm resistance to Bt corn hybrids:

- Crop rotation – Rotate fields annually between corn and nonhost crops. If practical, use a two to four year rotation between corn plantings.
- Control volunteer corn and grassy weeds that can serve as hosts for local Bt-resistant rootworm populations.
- Plant a conventional (non-Bt) corn hybrid and use a soil insecticide instead of a Bt hybrid, especially when rootworm pressure is expected to be low. **Note:** Combining a Bt hybrid with a soil insecticide is not recommended because the soil insecticide does not result in additional yield protection beyond what the Bt insecticide provides. Soil insecticide use also prevents detection of Bt-resistant insect populations.
- Plant the required non-Bt corn refuge according to guidelines on the Bt corn seed bag tag.
- Rotate different Bt corn hybrid modes of action each year. For example, use a Cry 3 Bt corn hybrid such as Cry3Bb1, mCry3A or eCry3.1Ab the first year, then switch to a Bt corn hybrid expressing a different mode of action (for example, Cry34/35Ab1) in the subsequent year.
- Be vigilant in scouting fields for corn rootworm adults and assessing the larval root-feeding injury.
- Report suspected performance problems immediately to your local seed dealer and to NDSU Extension Entomology.

Warning Signs of Emerging Corn Rootworm Bt Resistance

- High corn rootworm beetle infestations in Bt corn during late summer
- Severe leaf-feeding and/or silk-feeding injury by adults in Bt corn
- Rootworm node-injury scores of at least 1 (or equivalent of one complete node consumed) on single-protein Bt corn hybrids, or 0.5 on pyramided Bt corn hybrids
- Significant corn plant lodging or goose-necking present in Bt corn hybrids

It is important to keep accurate records each year for individual fields. This includes corn hybrid(s) planted, larval root-feeding injury scores by hybrid, and rootworm adult counts per trap or per plant.

Early detection of corn rootworm resistance to Bt corn will reduce the risks of economic loss and will help promote the long-term sustainability of this technology for rootworm management in your area.

Chemical Control

Remember to use the recommended thresholds before deciding to use a chemical insecticide. Insecticides come in granular or liquid forms and can be applied at planting as soil insecticides or postemergence as foliar insecticides.

Planting-time soil insecticide applications can be placed in-furrow or as t-bands to control corn rootworm larvae, and as foliar applications for adult control. Soil insecticides provide a zone of protection around roots and typically result in about 70 percent larval mortality. Insecticidal seed treatments also are available, but provide minimal protection from corn rootworm larval root-feeding injury. They mostly are intended for protection from secondary pests, such as wireworms and white grubs.

The use of foliar insecticide applications to control adults is uncommon in North Dakota. If more than one application of foliar insecticide is made, rotate the insecticide class to prevent rootworm populations from developing insecticide resistance.

Hot, dry weather conditions will favor spider mite outbreaks in corn. To prevent such spider mite "flares," avoid using pyrethroid insecticides for adult rootworm control (except for products containing the active ingredient bifenthrin). The pesticide label is a legal document, so applicators must **read, understand, and follow all label directions.**

For help with selecting a registered insecticide for corn rootworm control in North Dakota, consult the current "North Dakota Field Crop Insect Management Guide" (NDSU Extension publication E1143-22). The web link to this document is listed below in the Selected References section.

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For more information on this and other topics, see www.ag.ndsu.edu

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