# Managing Corn Rootworms



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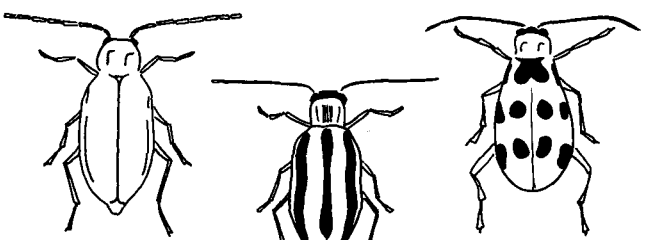
If you farm in the southern half of Minnesota and plant corn in fields that were in corn the year before, you can expect infestations of corn rootworms. Infrequently, localized infestations also occur in Minnesota's more northern corn-growing areas.

Two species of corn rootworms damage Minnesota corn: the northern corn rootworm, *Diabrotica barberi,* and the western corn rootworm, *Diabrotica virgifera virgifera.* Since the winter of 1976-1977, the more winter-hardy northern corn rootworm has become the most abundant and now is over 90 percent of the population statewide. The more aggressive western corn rootworms, which are favored by mild winters and continuous corn production, currently are prevalent only in areas of southeastern Minnesota. A third species, the southern corn rootworm or spotted cucumber beetle, *Diabrotica undecimpunctata howardi,* rarely causes problems and cannot overwinter in Minnesota.

**Figure 1. Adult rootworm beetles.**



**Northern**
adults ¼-inch long;
solid green or tan

**Western**
adults ¼-inch long;
yellow with black stripes

**Southern**
adults ¼-inch long;
yellow with black spots

## LIFE CYCLE

Both the northern and western corn rootworms have similar life cycles. Eggs of these beetles overwinter or diapause (are in a resting state) in the top 8-12 inches of soil in previous corn fields. Most eggs hatch the next year in mid-June but hatching may extend over several weeks.

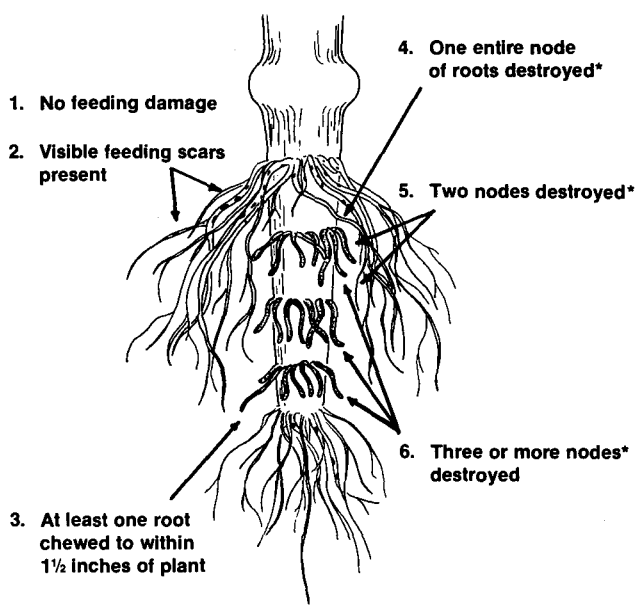
At hatch, the slender, 1/16-inch, whitish larvae migrate through the soil in search of corn roots. Although some larvae may move up to 3 feet in lighter soils, compaction and heavy soils can severely limit movement. Most larvae die from starvation if they hatch more than 1.5 feet from their food source. The young larvae feed on root hairs and tunnel in smaller roots. As larvae grow in size and appetite, they feed both internally and externally on larger roots. Pruning of nodal roots (including brace roots) in the upper root system is most severe in mid-July when older larvae, up to 5/8-inch long, predominate. These larvae have dark-brown, shiny heads, white to cream bodies, and a dark brown area on the top of the tails.

When fully grown, larvae form a cell in the soil and pupate for about a week while undergoing the transformation to adult beetles. Peak emergence of adult beetles is usually reached in early August. Western corn rootworms emerge about one week ahead of northern corn rootworms. Males emerge a few days before females. The primary function of adult corn rootworms is to mate, produce eggs, and search out an appropriate place to lay eggs. Adult beetles prefer feeding on corn silks, ear tips, and pollen: a diet that promotes adult longevity and egg production. Northern and western corn rootworms, however, differ somewhat in their dispersal. Western corn rootworms can readily move great distances, up to 200 miles, before laying eggs. In contrast, the northern corn rootworm is thought to lay the majority of its eggs within a short distance — less than 2 miles — of the field where it emerged. Both corn rootworm species orient strongly to corn for egg laying. The highest concentrations are found near the base of corn plants and in soil cracks. As pollen and fresh silks disappear from the field, beetles migrate into later-planted corn and to alternative pollen sources, such as goldenrod and flowering weeds. Even after leaving corn fields to feed, beetles return to corn to lay eggs, an activity which may occur until the first heavy frost.

## DAMAGE

Figure 2 illustrates damage to corn roots, and a 1 to 6 scale that rates the proportion of the root system destroyed. The ultimate economic impact of this damage is extremely difficult to predict and researchers throughout the Midwest have been unable to demonstrate a consistent relationship between damage and yield or lodging. The number and species composition of the larvae, the size of the root system, moisture and nutrient availability, hybrid variation in root regenerative ability, and seasonal weather conditions all affect the level of damage and its impact on yield and lodging. At a root rating of 3 or more, lodging and yield reductions are possible.

**Figure 2. Rating system for corn rootworm injury to root.**




Courtesy of Iowa State University

* It is not necessary for all pruned roots to originate from the same node, just that the number of roots pruned is equivalent to a full node.

Larval feeding directly reduces yield by impairing water and nutrient uptake. Direct yield losses are most evident when the plant is already under stress from drought, for example, and root regeneration is retarded. Root pruning also increases susceptibility to lodging, the usual symptom associated with corn rootworm damage, and provides a route of entry for stalk rot fungi. Thunderstorms with strong wind and heavy rains lodge damaged corn in August or early September after corn rootworm injury is completed. If lodging occurs early enough, the upper part of the plant may curve upwards or straighten up, producing a symptom called "goose-necking." Although lodging may affect yield directly, increased harvest losses and harvest costs (increased time and fuel) are more important considerations. In some years when conditions favor root regeneration and brace root formation or if severe thunderstorms do not occur, yield reductions and lodging may not occur.

Lodging may occur in the absence of corn rootworm damage. The only ingredients required are rain and heavy winds. A poorly developed or damaged root system, regardless of the cause (compaction, rainfall, or disease) will favor lodging. Therefore, it is important to verify that rootworms caused the lodging by digging up corn roots, washing them off with water, and examining them for feeding scars and root pruning (figure 2).

Adults feed on corn leaves, tassels, silks, and ear tips. Usually this damage will not affect yield. One situation, however, may cause yield loss. If enough beetles emerge before pollination and the feeding keeps silks pruned to less than ½-inch exposed during pollination, barren or partially barren ears may result. This problem is most likely when drought hampers pollination. Reduced levels of silk feeding during or after pollination will not reduce yields.

## CULTURAL MANAGEMENT OF CORN ROOTWORMS

### Crop Rotation

Very few corn rootworm eggs are laid outside corn fields and most corn rootworm eggs hatch the next spring. Corn rootworm larvae have a very limited host range and can only survive on the roots of corn and a few grasses. The best tactic to avoid corn rootworm damage is not to grow corn where corn was planted last year. A single year's rotation usually eliminates resident corn rootworms, particularly westerns, and the field must be recolonized before later problems can develop. Rotating crops, such as corn/soybean rotation, also provides additional advantages in fertility, tillage, weed control, and yield.

### Extended Diapause

Isolated occurrences of northern corn rootworm damage in corn/soybean and corn/small grain rotations have been observed in Minnesota over the last 15 year. For the first time in 1985 and, to a lesser degree in 1986, this pattern developed on a larger scale in west central, southwest, and south central Minnesota, as well as northwest and central Iowa, and eastern South Dakota. Traditionally, such damage has been attributed to egg laying near volunteer corn or weeds in soybeans, or near foxtails in volunteer small grain. But new evidence indicates problems result from the ability of northern corn rootworm eggs to successfully overwinter two or more winters. This ability to remain in a resting state longer than the usual single winter is called "extended diapause." In the mid-1960s, less than 0.2 percent of the northern eggs had this ability. In contrast, a 1985 study reported as many as 40-50 percent of the eggs from areas with strong crop rotation exhibited extended diapause. The problem is still relatively rare and its first occurrence is extremely difficult to predict at this time. Fields with a previous extended diapause problem are likely to suffer damage again.

### Late Planting

Planting date determines size of the corn root system and the probability that hatching larvae will successfully find it. Early planted corn with its larger root system will suffer more damage than late planted corn with a smaller root system. Deliberately delaying planting dates to avoid corn rootworm damage is not a practical idea under Minnesota conditions. However, for corn planted after June 7, no insecticide is necessary.

### Other Soil and Cultural Factors

A number of other factors influence the damage caused by corn rootworms. Corn is not resistant to larval feeding. varieties differ in the ability to tolerate corn rootworm injury because of the root system's architecture and ability to regenerate. Corn rootworm damage in sandy, heavy muck, or peat soils is rare compared to other soil types in Minnesota. Manure applications also result in less corn rootworm injury. Commercial fertilizers, including anhydrous ammonia, and tillage systems have little impact on corn rootworm injury. Environmental conditions and cultural practices favorable to corn growth usually will reduce the impact of corn rootworm injury.

## MONITORING CORN ROOTWORM POPULATIONS

Monitoring corn rootworm populations is important to avoid economic damage, lodging, and the unneccessary expense, environmental and health risks of soil insecticides. The easiest and most reliable method of monitoring corn rootworm populations is to count adult beetles. A population of one adult western corn rootworm per plant can cause enough injury to warrant crop rotation or the use of soil insecticides. The number of adult northern corn rootworms needed to cause equivalent damage is unknown but assumed to be two per plant.

Sampling should begin about one week after adult emergence, about August 1, and should continue weekly throughout August. Late-planted or late-maturing fields attract beetles from surrounding fields and may need to be monitored through mid-September. Beetles should be counted using the "whole plant" method. To avoid disturbing the flighty beetles, approach the plant quietly while scanning the whole plant. Grasp the ear tip and silks with one hand. Examine the leaves, especially where the leaf joins the stalk and tassel. Finally, release the ear tip, part the husks, and count any additional beetles on the silks. Either of the following sampling procedures can be followed. Scout the field in an inverted U-shaped pattern. Avoid the edge of the field by taking at least 50 paces before the first count and walking at least 25 paces between locations. **Count each northern corn rootworm as 0.5 beetle.**

### Sequential Sampling

This method minimizes your time in the field when populations are extremely high and low. Additional effort is required in populations bordering economic levels.

*Step 1* Sample two plants, about 10 plants apart, at each location. **Count each northern corn rootworm as 0.5 beetle.**

*Step 2* After sampling 5 locations and for each subsequent location consult the decision table (table 1).

*Step 3* If the population is in the "low" category, quit sampling and return in 7 days. If the population remains in the low category, crop rotation or insecticide use are unnecessary.

*Step 4* If the population is "high," quit sampling for the season and choose between crop rotation and soil insecticide use. Sufficient eggs may be laid to cause economic damage next year.

*Step 5* If the population falls in the "undecided" category, sample another location. If a decision has not been reached in 50 plants, quit sampling and return in 7 days.

**Table 1. Decision table for sequential sampling of adult corn rootworms**

| No. plants sampled | Total beetle count* | | |
|---|---|---|---|
| | Resample in 7 days if less than: | Continue sampling if between: | Rotate crops or use soil insecticide if greater than: |
| 10 | 2 | 3-17 | 18 |
| 12 | 4 | 5-19 | 20 |
| 14 | 6 | 7-21 | 22 |
| 16 | 8 | 9-23 | 24 |
| 18 | 10 | 11-25 | 26 |
| 20 | 12 | 13-27 | 28 |
| 22 | 14 | 15-29 | 30 |
| 24 | 16 | 17-31 | 32 |
| 26 | 18 | 19-33 | 34 |
| 28 | 20 | 21-35 | 36 |
| 30 | 22 | 23-37 | 38 |
| 34 | 26 | 27-41 | 42 |
| 38 | 30 | 31-45 | 46 |
| 42 | 34 | 35-49 | 50 |
| 46 | 38 | 39-53 | 54 |
| 50 | 42 | 43-57 | 58 |
| Population category: | LOW | UNDECIDED | HIGH |

*Count each northern corn rootworm as 0.5 beetle.

**50 Plant Count**

*Step 1* Count the beetles from 5 plants at 10 locations scattered throughout the field in an inverted U-shaped pattern. **Count each northern corn rootworm as 0.5 beetle.**

*Step 2* If the population falls below 1.0 beetle per plant, quit sampling and return in 7 days. If the population remains below 0.8 beetles per plant throughout the season, no soil insecticide is required to plant corn next spring. If peak beetle count falls between 0.8 and 1.0 beetle per plant, an insecticide may be beneficial.

*Step 3* If the population averages more than 1.0 beetle per plant, crop rotation or a soil insecticide is recommended.

## MANAGEMENT OF CORN ROOTWORMS WITH INSECTICIDES

### Larval Control

A soil insecticide is recommended in Minnesota whenever corn is planted after corn with one exception. A soil insecticide is not recommended if the field has been monitored for corn rootworm adults and counts average less than 1.0 beetle per plant. Table 2 presents the soil insecticides recommended for controlling larval corn rootworms. These insecticides are designed to protect the core of the corn root system and doing so, prevent lodging. SOIL INSECTICIDES DO NOT PROVIDE 100 PERCENT or even 90 percent CONTROL OF LARVAL CORN ROOTWORMS. The

**Table 2. Factors to consider when choosing a soil insecticide for corn rootworms**

| Factor | Organophosphates | | | | Carbamates | | |
|---|---|---|---|---|---|---|---|
| | terbufos (Counter 15G) | fonofos (Dyfonate 20G) | chlorpyrifos (Lorsban 15G) | ethoprop (Mocap 15G) | phorate (Thimet 20G) | carbofuran (Furadan 15G) | trimethacarb (Broot 15G) |
| Performance in test plots | | | | | | | |
| Root damage rating[a] | 2.42 | 2.91 | 3.08 | 3.05 | 2.47 | 2.87 | 2.61 |
| Consistency (%)[b] | 95 | 63 | 50 | 60 | 94 | 67 | 93 |
| Yield (bu/acre)[a] | 128 | 124 | 128 | 122 | 126 | 124 | 128 |
| Technical information[c] | | | | | | | |
| Phytotoxicity-seed/seedling contact | L | M | L | H | M | L | H |
| Placement (label) | | | | | | | |
| Band behind presswheel | Y | Y | N | Y | Y | Y | Y |
| Band ahead presswheel | Y | Y | Y | N | Y | Y | Y |
| Infurrow | Y | N | N | N | N | Y | N |
| Human hazard (signal word) | | | | | | | |
| Granular formulation | D | D | C | W | D | W | C |
| Liquid formulation | — | D | W | D | — | D | — |
| Restricted-use pesticide | Y | Y | N | Y | Y | Y | N |
| Crops (besides field corn) | | | | | | | |
| Sweet Corn | Y | Y | Y | Y | Y | Y | N |
| Popcorn | Y | Y | Y | N | N | Y | N |
| Labeled for control of other soil pests | | | | | | | |
| Cutworms | N | Y | Y | Y | N | N | N |
| Nematodes | Y | N | N | Y | N | Y | N |
| Seedcorn maggot | Y | Y | Y | N | Y | Y | N |
| Whitegrubs | Y | N | N | N | Y | N | N |
| Wire worms | Y | N | N | Y | Y | Y | N |

[a]Based on 18 trials from 1977 to 1986 where root damage in the untreated check exceeded 3.0. Root damage rating and yield in the check averaged 3.99 and 118 bushels per acre, respectively.

[b]Consistency is the percentage of trials where the insecticide performed acceptably (root rating less than 3.0). The value is based on 26 trials conducted between 1977 and 1986. The untreated check did not exceed a root rating of 3.0 in 30.8% of the trials.

[c]Key to symbols: L = Low, M = Medium, H = High, Y = Yes, N = No, D = Danger, W = Warning, C = Caution, — = no liquid formulation.

[d]At labeled rate(s) and placement for corn rootworms.

performance of soil insecticides varies with a number of factors including proper application, the properties of the insecticide, soil conditions, and weather. For this reason, it's important to consider other factors besides cost when choosing a soil insecticide. These factors include long-term performance, label restrictions, and soil pest spectrum. Use table 2 information to pick the insecticide which best fits your situation.

Good insecticide performance involves more than choosing an insecticide. It must be applied at recommended rates, properly placed, and lightly incorporated. All currently recommended soil insecticides are applied at a rate of 1.2 ounces of active ingredient per 1,000 row feet. Table 3 summarizes the amount of insecticide required per acre.

Calibrate your insecticide applications often, at least once per year and every time you change insecticides. Although one 15 percent granular insecticide may look similar to another 15 percent granular insecticide, flow rates can differ substantially. Changes in field conditions, soil type, and humidity may require adjustments in settings. Use the labeled settings only as a starting point for calibration.

**Table 3. Amount (lbs.) of formulated granular insecticide needed to treat one acre for various row widths**

| Granules | Row width (in inches) | | | |
|---|---|---|---|---|
| | 30 | 36 | 38 | 40 |
| —percent— | — — — — — — pounds — — — — — — | | | |
| 10 | 13.3 | 11.1 | 10.5 | 10.0 |
| 15 | 8.7 | 7.4 | 7.0 | 6.7 |
| 20 | 6.7 | 5.6 | 5.3 | 5.0 |

Putting the insecticide in the right place is just as important as how much is applied. Follow label directions regarding placement to avoid performance and phytotoxicity problems. Placement and incorporation are closely related. Banding offers the greatest flexibility in product choice (table 2) but requires incorporation in the upper ¼-1 inch of soil for maximum performance. In a mellow seed bed, the action of the presswheel may adequately incorporate the insecticide. Spring tines or drag chains are needed to incorporate insecticides in rough or dry seed beds or when banded behind the presswheel. Strong winds can offset band placement, especially if applied behind the presswheel. Avoid band displacement by using windshields, waiting for calmer conditions, or if the label permits, applying the insecticide in-furrow. In Minnesota, in-furrow and banded applications ahead of the presswheel perform equally well.

Liquid formulations of Furadan, Dyfonate, and Lorsban are available for planting or cultivation applications. Like granular counterparts, liquids need to be covered with soil for maximum performance. These formulations can be mixed with liquid fertilizers in a split-boot application (split on each side of the row). Check compatability of the insecticide and fertilizer with a jar test. Generally, liquids give less consistent control than granular formulations.

Cultivation applications of the granular and liquid insecticides listed in table 2 can provide effective corn rootworm control. Treatments should be applied by June 15 and covered with moist soil to insure prompt activation. The only problem is the cooperation of weather during cultivation. In Minnesota, continuous wet weather may prevent timely insecticide application while droughty conditions reduce soil insecticide performance.

**Enhanced Biodegradation**

During the last 20 years it has become increasingly clear that soil micro-organisms can decrease the effective life of some, if not all, soil insecticides. Soil insecticides are designed to be biodegraded eventually by soil organisms. But with repeated soil insecticide use, this biodegradation process may be speeded up, leading to less effective control from insecticides. The interactive effects between soil insecticides or between soil insecticides and other soil additives are too poorly understood to recommend specific use patterns. Based on the little known about "enhanced biodegradation," the following suggestions are made to reduce the potential problem. First, rotate soil insecticides. Second, do not use carbamates in successive years or where a previous problem with carbamates has recently occurred. Finally, avoid unnecessary insecticide use through adult scouting.

**Adult Control**

If beetles become abundant in fields just at pollination, adult control may be economical. Usually corn is just past pollination when peak adult emergence occurs, but late-planted or late-maturing fields can attract damaging populations. Treatment is justified only if beetles exceed 10 or more per plant, silks are kept pruned to within ½-inch of the husk, and less than 50 percent of the plants have silked. Drought stress can accentuate pollination problems. Use 0.5 pound diazinon, 0.5 pound phosmet (Imidan), 1 pound malathion, 0.1 pound permethrin (Ambush, Pounce), 0.1 pound fenvalerate (Pydrin), 1 pound carbaryl (Sevin), or 0.5 pound methyl parathion (Penncap-M).

**Secondary Insect Control**

Rootworm insecticides applied at the labeled rates for corn rootworm vary in their ability to control other soil insects. Table 2 summarizes the spectrum of performance against soil pests for each insecticide. Some insects such as wireworms or white grubs are controlled better with in-furrow than with band applications. Rates of application needed to control other soil pests may be greater than the labeled rate for corn rootworms. When faced with multiple pest problems, determine the major pest, then select the insecticide, rate, and placement to control that pest. One product can't control all soil pest problems.

**Personal and Environmental Safety**

All corn rootworm insecticides are toxic and must be used with extreme care, regardless of restricted use status. Avoid exposure to skin, lungs, mouth, and eyes. Wear protective gear as directed by the manufacturer's label.

Respect these materials. Do not breathe dust or vapors and do not eat or smoke while handling these materials or until you've washed thoroughly. Always keep water and soap accessible where you handle these insecticides to wash after contact with insecticides. When you finish each day, bathe thoroughly and change and wash clothes which were worn.

Many of these insecticides can kill fish if streams or lakes are contaminated with runoff. Avoid band applications to corn on steep slopes. Rotate crops, if possible, and use recommended soil conservation practices.

Granular insecticides are also toxic to birds. Cover exposed granules if you spill granules while filling boxes.