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Corn Rootworms: Biology, Ecology and Management

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Corn rootworms are key pests of corn in Michigan and in other corn-growing areas of the U.S. Three different species of rootworms occur in Michigan. The western corn rootworm[1] is the most abundant, occurring throughout the state. The northern corn rootworm[2] is much less abundant but can have locally heavy populations. The southern corn rootworm[3] is not a pest of corn in Michigan but does attack various garden and vegetable crops. Both the western and northern corn rootworms have a similar life cycle and will be the primary focus of this bulletin.

I. Identification

Rootworm eggs are oval shaped, yellowish in color and are found in soil (Fig. 1A). Larvae are small, white to cream colored worms from 1/8 to 1/2 inch long (Fig. 1B). The larva has a brownish head and tail section with three pairs of legs near the head end of the body. Larvae are generally found in and on the roots of corn or in the soil around roots. The pupae are white in color and resemble the adults. They are found in soil near the roots of corn plants. Corn rootworm adults are approximately 1/4-inch long with long antennae. Western corn rootworm adults are yellowish with three black stripes down their wings (Fig. 1C). These wing stripes vary from thin streaks to nearly covering the entire wing. Northern corn rootworm adults are pale green without wing markings (Fig. 1D). Southern corn rootworm adults are larger than the other species, yellow to green in color and have 12 conspicuous black spots on their wing covers (Fig. 1E).

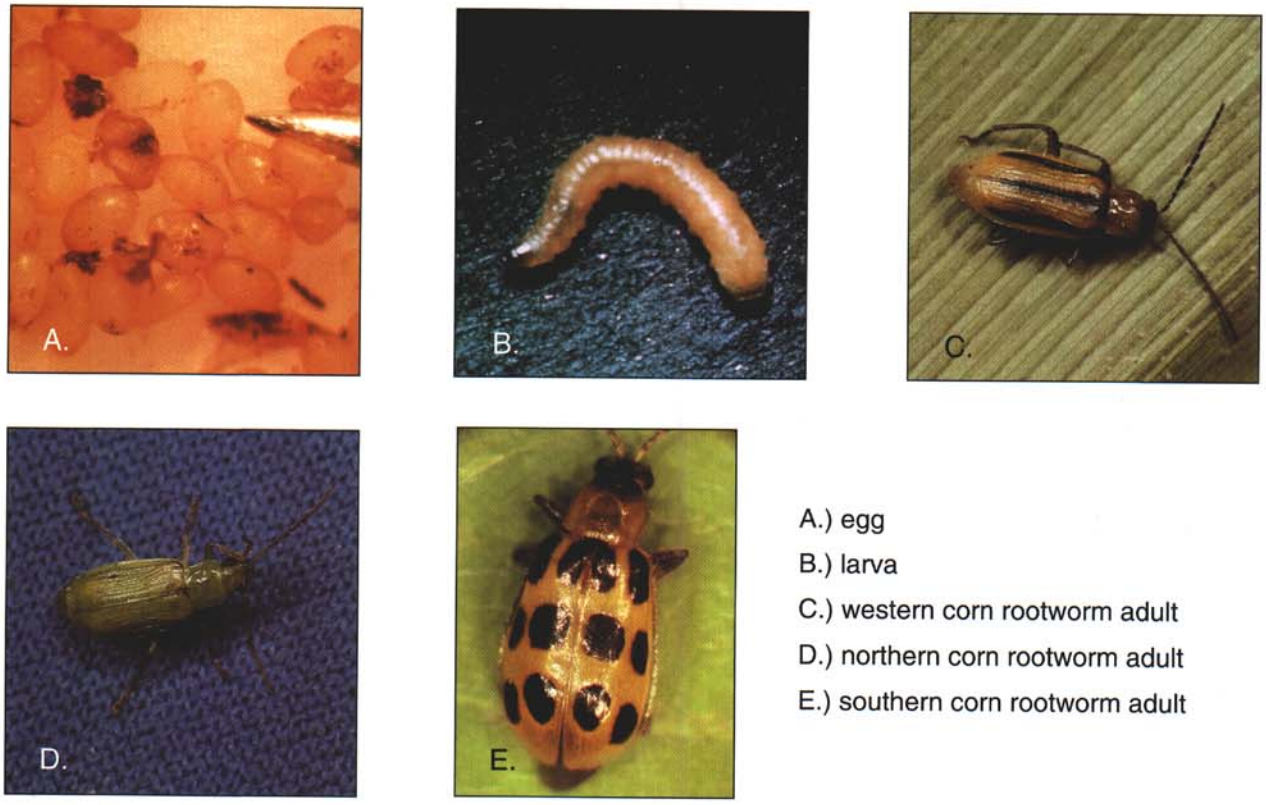
II. Life Cycle and Seasonal History

Western and northern corn rootworms have similar life cycles. They complete one generation per year and pass through four stages: egg, larva, pupa and adult (Fig. 2). Rootworm eggs are laid in soil near corn plants in August-September and hatch during early to mid-June of the following year. Soil temperature is a predominant factor affecting the time of egg hatch and larval development. The larvae feed on corn roots for several weeks before pupating in the soil in mid-July. The adults emerge from the soil during late July or early August. Adults prefer to eat fresh corn silks, but will also feed on leaf tissue, tassels and pollen. After feeding and mating, and a period of egg development, females lay eggs in the soil in corn fields. Females may crawl down earthworm burrows or soil cracks and can lay eggs as deep as 12 inches or more. These eggs overwinter until the following year.

Adult corn rootworms are attracted to a variety of flowers such as squash, cucumber and wild carrots, where they feed on pollen. Movement of adults within and between fields is common, and they remain active until the first hard frost kills

[1] *Diabrotica virgifera virgifera* Laconte
[2] *Diabrotica barberi* Smith and Lawrence
[3] *Diabrotica undecimpunctata howardi* Barber

Figure 1. Corn Rootworm



A.) egg
B.) larva
C.) western corn rootworm adult
D.) northern corn rootworm adult
E.) southern corn rootworm adult

them. The southern corn rootworm overwinters as an adult in Michigan. Beetles emerge on warm days in the spring and begin to feed and lay eggs.

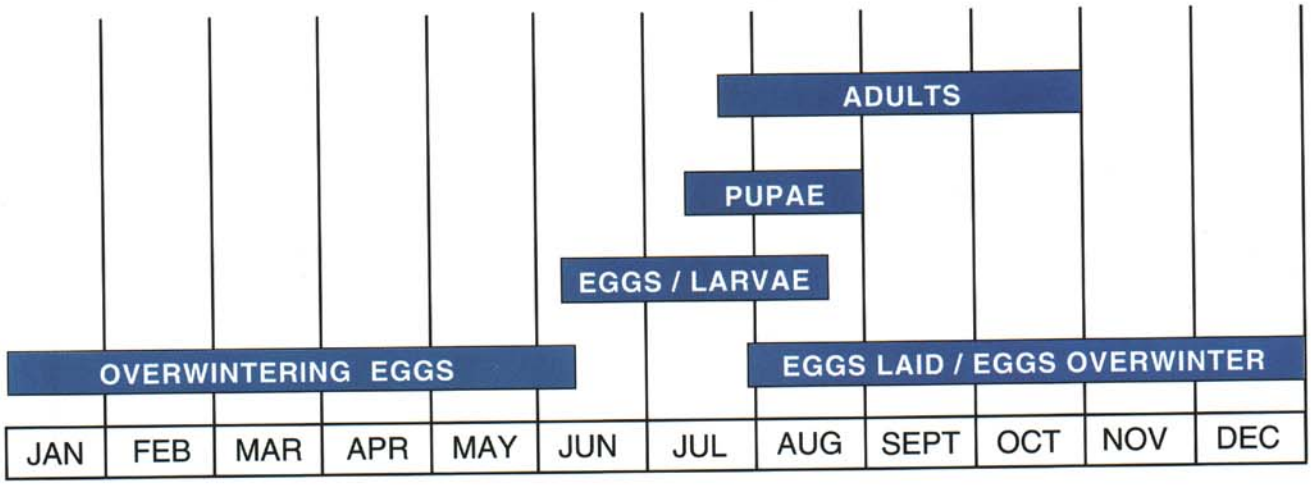
III. Damage

Larval feeding: Western and northern corn rootworm larvae feed on the roots of corn and a few grass species. Southern corn rootworm larvae feed on the roots of many plants, including corn, soybean, sorghum, wheat, cucumber, other vegetables and many legumes. However the greatest damage to corn in Michigan is done by the larvae of the western corn rootworm which feed almost exclusively on corn. Rootworm larvae

Table 1

Root Rating	Description of Damage
1	No visible root feeding damage.
2	Some feeding scars present, but no roots pruned to within 1.5 inches of the plant.
3	At least one root pruned to within 1.5 inches of plant, but less than a full node pruned.
4	One complete node of roots pruned to within 1.5 inches of the plant.
5	Two complete nodes of roots pruned to within 1.5 inches of the plant.
6	Three or more entire nodes of roots pruned to within 1.5 inches of the plant.

Figure 2



Life cycle and seasonal history of corn rootworm in Michigan. Times for various activities will vary with latitude and environmental conditions.

have chewing type mouthparts. Larvae consume small roots and also tunnel inside the larger primary and brace roots.

Larval feeding can reduce vigor and weaken the plant. Seriously damaged plants may fall over (lodge) in high winds or in wet soils. These lodged plants attempt to grow upright, resulting in the typical curved "goosenecked" stalk (Fig. 3). The extent of larval feeding is evaluated by examining roots for damage. This is best done after peak larval feeding and when three root-nodes are clearly visible. The most commonly used rating system is the "Iowa" or "Hills and Peters" 1 to 6 scale (Table 1 and Fig. 4). Potential economic yield loss may occur when root ratings exceed a level of 3. Yield loss may or may not occur depending on the weather, tolerance of corn hybrids to damage

Figure 3

"Goosenecked" stalk resulted from corn rootworm larval root feeding damage.

Figure 4

Corn rootworm larval root feeding damage (left to right, 6-1 on "Iowa" scale).

Figure 5A

Adult corn rootworm silk feeding damage.

and root re-growth potential. Under good growing conditions root ratings of 3.5 to 4 (or more) may be necessary before economic damage occurs.

Adult Feeding: The preferred food of the adult rootworms is corn silks and pollen. They also feed on pollen of other crops and weeds when corn pollen is no longer available. Silk feeding may interfere with pollination if an insufficient length of silk extends from the husk (Fig. 5A). Poor pollination reduces seed set. Western corn rootworm adults will also feed on tender leaves if silk and pollen are not available. Leaf feeding results in the removal of the green upper surfaces of leaves, but is not important (Fig. 5B).

IV. Scouting or Monitoring

Scouting for adult rootworms is done for two reasons: one is to determine if adults may reduce pollination by excessive silk feeding; the other is to predict the risk of larval feeding damage in that field for the next year if planted again in corn. Scouting for silk damage should be timed to occur just before and during pollination. When scouting for silk damage, check 20 plants at five different locations in the field. Consider treatment if silks have been clipped shorter than a half inch, pollination has not occurred and adults are actively feeding.

For predicting the potential number of eggs laid and subsequent larval pressure in the following year, scouting for adults should begin 18 days after the first sighting of adults. Scouting is done by walking into the field (beyond field margins and border rows) and counting the number of rootworm adults visible on 60 consecutive plants at three locations in the field. Examine the entire plant but do not turn over leaves or peel back silks. If a total of 180 or more adults are observed on the 180 plants examined (i.e., an average of 1 beetle per plant), a threshold is reached and treatment is recommended. If not, continue scouting on a weekly basis until either a threshold is reached or until the adult numbers decline to low levels. Adult numbers normally decline when all silks in the field turn brown and dry up, but they may remain high for reasons not fully understood. Fields that silk or remain green after other nearby fields have begun to dry up are especially prone to late season egg laying and should be scouted until first frost.

Figure 5B

Leaf-feeding damage from adult corn rootworms.

Figure 6

Factors Affecting Rootworm Abundance and Damage Potential

- Continuous planting of corn
- Silking dates
- Soil type
- Soil temperature
- Soil moisture
- Volunteer corn and weeds

V. Corn Rootworm Management

Factors affecting rootworm abundance and damage potential (Fig. 6).

Continuous planting of corn: Corn rootworms lay most of their eggs in corn fields. Eggs overwinter and hatch the following spring. Since corn rootworm larvae feed almost exclusively on corn roots and can move only a few feet, continuous planting of corn in the same field favors their abundance and damage.

Silking dates: Fields that silk late, due to maturity variation in hybrids or planting date differences, often attract high adult rootworm numbers. As silks in other fields dry up, adults move into and concentrate in late-silking corn fields, leading to increased egg laying in these fields.

Soil type: Coarse-textured soils tend to have considerably reduced rootworm damage. Survival of the eggs and young larvae is poorer in sandy soils. The cuticle or "skin" of larvae moving through sandy soils can get scratched, causing the larvae to loose moisture and die. Fine-textured soils provide better environments for rootworm survival.

Soil temperature: Egg survival in the soil during the winter is affected by soil temperature. Lack of snow cover may contribute to egg mortality by allowing the soil to freeze more deeply. Mild winters favor egg survival.

Soil moisture: Corn rootworm adults prefer to lay eggs in moist rather than in dry soil. Females lay eggs near the soil surface if soil moisture is high. Dry conditions during the winter have a negative affect on survival of these eggs.

Volunteer corn and weeds: Volunteer corn plants serve as a food source for the larvae and the adults emerging from the previous year's egg deposition. Weeds may also serve as alternate food (pollen) sources for adults. Volunteer corn and weeds may attract adult rootworms from neighboring corn fields and may result in egg deposition. However, the impact of volunteer corn is usually slight.

Current Management Trends

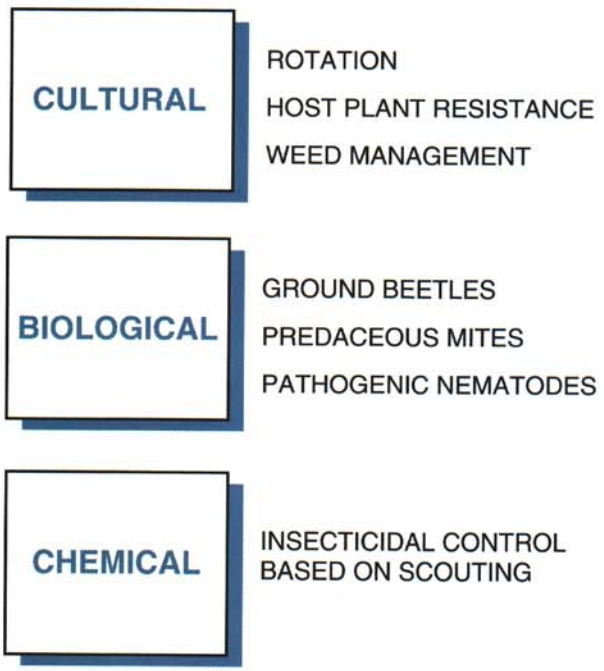
Michigan corn growers use several approaches to manage corn rootworms. Most growers rotate corn with another crop to break the life cycle of rootworms. Others grow corn following corn and use soil insecticides to manage rootworms regardless of pest densities. Increasingly growers are adopting scouting as a way to determine if rootworm pressure is great enough to justify use of a soil insecticide. Some growers use a soil insecticide as a preventive or insurance treatment in first year corn. This practice is not necessary, nor recommended. Rootworms are almost never a problem in first year corn.

Rootworm Management Methods (Fig. 7).

A. Cultural Practices:

Rotation: Crop rotation is the most ecologically sound approach to manage rootworms as it

Figure 7



Integrated management of corn rootworms.

eliminates the need for insecticides. Because adult rootworms lay the vast majority of their eggs in corn fields and rootworm larvae can move only a few feet to feed on corn roots, rotation of corn with any other crop provides effective rootworm control.

Some northern corn rootworm eggs may not hatch until the second spring due to a "prolonged diapause" (dormancy). These eggs remain in the soil for two or more winters before hatching. In some states where the northern corn rootworm is very abundant, this has resulted in damage on corn in a two-year rotation program (eg. corn, beans, corn). Since the northern species is present in low numbers in most parts of Michigan, extended diapause of this species has not been an important factor.

Rotation is also a good management option because it reduces the possibility of corn rootworms developing resistance to a particular insecticide. Historically, insecticide resistance has occurred when insects are continuously subjected to selection pressure from insecticide use. For corn rootworms, resistance has not been a recent problem, although organo-chlorine resistance was a problem in the 1960s.

Host Plant Resistance: No commercial corn hybrids are available which possess true resistance to corn rootworms. However, hybrids with large root systems and good root regeneration capability are available and are more tolerant to rootworm damage.

A deep rooted hybrid under good growing conditions may rapidly outgrow rootworm damage. The degree of root recovery following damage varies according to the corn hybrid planted and environmental conditions. The effect is usually expressed by the development of a massive fibrous root system. Hybrids with long root systems are less prone to lodge as a result of root damage.

Weed management: A good weed control program aids early plant growth largely by reducing competition for light, nutrients and moisture. Good weed control may somewhat reduce attractiveness of corn fields to rootworm adults by providing less shade and protection and eliminating other sources of pollen. Any cultural practices that encourage rapid corn growth help reduce the effects of rootworm damage. Early planting allows silks to develop before peak rootworm beetle feeding.

B. Biological Control

Some predaceous ground beetles and mites in the soil feed on eggs, larvae and pupae of rootworms. However, natural enemies of rootworms do not generally have a major impact on their numbers. A biological control method using nematodes that infect rootworm larvae is being investigated.

C. Chemical control

An economical and ecologically sound rootworm management program should be based on determining if a rootworm problem actually exists before applying an insecticide.

Silk Feeding: Treat only if silks are clipped shorter than 1/2 inch before pollination occurs and if adults are still active. If more than 1/2 inch of silk is protruding from the husk, adequate pollination will occur and no damage to yield should result.

Root Feeding: During scouting if a total of 180 adults are observed on the 180 plants checked in the corn field (i.e. 1 beetle per plant) consider a soil insecticide treatment in that field if planted with corn in the following year. Factors that affect larval survival may also alter a management decision. A field where adult rootworm counts were slightly above threshold may not require treatment with a soil insecticide if the field has been exposed to very dry soil conditions or extremely cold periods without snow cover. Because of reduced egg and larval survival, some producers find that fields with lighter soils may not benefit from treatment if beetle counts are only slightly above threshold.

Factors that affect the performance of soil insecticides include proper calibration, timing of application, placement, incorporation, planting date, soil type, rainfall and temperature. Under unfavorable conditions or extreme rootworm pressure, soil insecticides may fail to provide adequate control.

New developments in corn rootworm management

As concerns regarding economic, environmental and human health increase, less chemically intensive approaches to rootworm management may be required. This will necessitate greater adoption of integrated pest management (IPM) practices. IPM approaches include regular scouting and use of rotation or insecticides when populations exceed thresholds. Sound crop management and conservation of biological control agents help prevent rootworm problems.

In the future, corn growers will have additional techniques available for corn rootworm management. Optimizing rates of soil insecticides to meet field conditions and rootworm population levels will allow lower rates to be used in many situations. Corn growers and researchers have examined the effectiveness of reduced rates of some soil insecticides for corn rootworm management with good success. Control of corn rootworm adults to prevent egg laying is also being examined. To be effective, this technique requires precise scouting information and usually several well-timed pesticide applications by air. A new technique is being developed using attractants to cause corn rootworm adults to feed on a bait containing a low rate of insecticide. Check with your local Michigan State University Extension office for current chemical control recommendations and new techniques for managing corn rootworms.

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