Corn Rootworm Management

Two species of corn rootworms—the northern and western (figure 1)[1]—are capable of causing severe yield reductions. Because of this damage potential, more than six million acres of Iowa's corn are treated with a rootworm insecticide each year. Not all of these fields have damaging rootworm populations, and many would not need a soil insecticide treatment. This pamphlet discusses the life cycle and damage of the rootworms and provides information that should help farmers make management decisions regarding them.

Life Cycle

The northern and western corn rootworms have a similar life cycle. Female beetles deposit eggs in the top 8 to 12 inches of soil, primarily in corn fields. The eggs overwinter in the soil and hatch the following June. If corn is planted in the same field, the larvae will feed on the roots during June and July. Larvae will not damage other crops such as soybeans, sorghum, or oats.

The larvae are white with a brownish head and a brown plate on the top side of the last abdominal segment. Three pair of small legs are present near the head end. The larvae range in size from a few millimeters (first instar) up to ½-inch long (third instar). All three larval instars feed on corn root tissue. After the destructive larval stage is completed, pupation takes place. This nonfeeding stage precedes the emergence of the adults.

Northern
Adults ¼-in. long; solid green or tan.

Western
Adults ¼-in. long; yellow with black stripes.

Southern
Adults ¼-in. long; yellow with black spots.

Fig. 1. Adult Rootworm Beetles.

Adult beetles start to emerge in early July, and emergence continues throughout August. Peak emergence occurs in late July and early August. After about two weeks as adults, the females begin laying eggs. Peak egg laying in corn fields occurs from August 10 to 30. During late August and early September, beetles will congregate in fields or areas of fields where younger plants (green leaves and/or silks) are still present. These areas may serve to concentrate egg laying later in the season.

The larvae of a third species of corn rootworm—the southern (figure 1)[2]—also feed on corn roots. The southern corn rootworm does not overwinter in Iowa. Adults fly into Iowa from the south in late May and June

[1]Northern corn rootworm, *Diabrotica barberi;* western corn rootworm, *Diabrotica virgifera virgifera.*
[2]Southern corn rootworm, *Diabrotica undecimpunctata howardi.*

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and lay eggs in corn fields. The larvae feed on roots, but not enough are present in any one field to cause significant damage by themselves. They may, however, add to the damage done by the other two species.

Damage

Larvae

Small rootworm larvae feed on small rootlets, scar roots, and tunnel inside the larger roots. Continued feeding by larger larvae may result in extensive tunneling and pruning of the major nodal roots (including brace roots) of the plant. The impaired ability of damaged plants to take up water and nutrients from the soil may result in physiological yield losses. Damaged plants also may lodge as a result of the loss of support from the roots. After the larvae pupate and the plants regenerate roots, the plants may straighten, resulting in the typical "gooseneck." Direct loss of the ears and added harvest costs (increased time and fuel) are a result of lodging.

Research throughout the Midwest has been unable to demonstrate a consistent relationship between rootworm damage and yield reduction. Numerous factors influence the extent of the damage and the resulting impact of the damage upon the yield. The number of larvae, the size of the root system, the availability of moisture and nutrients, the root regenerative ability of the hybrid, and weather conditions are all involved in the amount of damage that may occur in any given year and in the loss of yield resulting from the damage. If stress levels on the plant are minimal (for example, when there is optimum moisture, nutrients, and plant populations), severe root feeding may not result in significant yield loss, particularly if high winds do not cause lodging. If stress levels on the plant are high, it is likely that root feeding will be more directly related to yield losses.

Table 1. Sequential sampling table for corn rootworm beetles in continuous corn fields.

	Number of beetles found		
No. plants sampled	Discontinue sampling; Resample in 7 days	Continue sampling	Discontinue sampling; Rotate or use insecticide
10	2	3-11	12+
12	3	4-12	13+
14	4	5-14	15+
16	6	7-15	16+
18	7	8-17	18+
20	8	9-18	19+
24	11	12-21	22+
28	14	15-23	24+
32	16	17-26	27+
36	19	20-29	30+
40	22	23-31	32+
44	24	25-34	35+
48	27	28-37	38+
52	30	32-41	41+
54	31	32-41	42+

Adults

Adults of all three species may feed on corn leaves, but this causes little damage. The beetles also feed on silks and pollen. If enough beetles emerge before pollination, the beetles' silk feeding may reduce pollination and seed set. Barren or partially barren ears result. Silk feeding after pollination causes no damage.

Monitoring Corn Rootworm Beetles

The objective of monitoring corn rootworm beetle populations is to determine if enough beetles are present for the potential of economic larval damage the following season. It is considered that populations in continuous corn fields exceeding an average of 0.7 beetles per plant may result in sufficient damage to warrant rotation to another crop or a planting-time insecticide treatment. Because of the higher proportion of females present in first-year corn fields, the threshold is lowered to 0.4 beetles per plant in first-year corn.

The use of the sequential sampling method is recommended for both continuous (table 1) and first-year (table 2) corn fields. Sampling

Table 2. Sequential sampling table for corn rootworm beetles in first-year corn fields.

Number of beetles found			
No. plants sampled	Discontinue sampling; Resample in 7 days	Continue sampling	Discontinue sampling; Rotate or use insecticide
10	—	0-8	9
12	0	1-9	10
14	0	1-9	10
16	1	2-10	11
18	2	3-11	12
20	3	4-12	13
24	4	5-13	14
28	6	7-15	16
32	7	8-16	17
36	9	10-18	19
40	10	11-19	20
44	12	13-21	22
48	14	15-23	24
52	15	16-24	25
54	16	17-25	26

should begin about August 1 and be repeated weekly as needed through the first week of September. Fields that are especially attractive to adults in late August and early September (late-planted or late-maturing fields) may need to be scouted well into September.

The sampling technique used is called the "whole plant count" and simply involves counting all the beetles on a single plant. The technique used in making plant counts will determine the accuracy of the population estimates obtained. To avoid disturbing the adults on the plant to be counted, the plant should be approached quietly while observing beetles that are present on the leaves, tassels, and silks. The ear tip and silks should be grasped with one hand, and the upper and lower surfaces of each leaf, the tassel, and the leaf axils should be examined for adult beetles. Finally, the ear tip should be examined for beetles hidden within the silks. Two plants should be sampled at each location, with the plants far enough apart (about 10 plants apart) so that counting the beetles on the first plant does not disturb the beetles on the second plant. The field should be scouted in an inverted U-shaped pattern (see figure 2). The first pair of samples should be taken approximately 50 paces past the end rows; there should be at least 25 paces between each pair of samples.

After the beetles have been counted on 10 plants (five sites), consult the sequential sampling table for continuous corn (table 1), or for first-year corn (table 2). If fewer than 3 beetles were counted in continuous corn, sampling may stop for that day and resume the next week. If more than 11 beetles were observed, sampling may stop for the season for that field because an economic population of beetles is present. Sufficient egg laying may occur to cause economic damage to corn the next year.

If, however, between 3 and 11 beetles are observed, additional plants must be sampled that day. After each additional pair of plants is sampled, consult the table again to determine if sampling may stop. This procedure continues until a decision can be made to stop because of either low or high beetle counts. If after 54 plants (27 sites) are sampled and a decision still cannot be made to stop (32 to 41 beetles are found), sampling stops for that day and the field is resampled the next week.

Crop Rotation

Rootworm control can be achieved most effectively by not growing corn where corn was grown the previous year. Many Iowa farmers have adopted a corn-soybean rotation and eliminated the use of a rootworm insecticide.

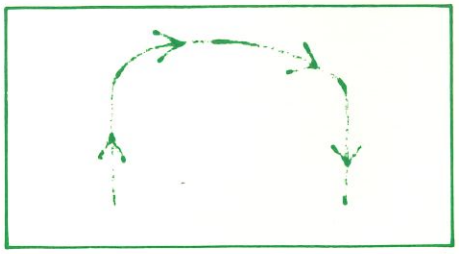

Fig. 2. Sampling route.

Table 3. Recommended rootworm insecticides.

Insecticide	Rate per acre or 13,068 ft. of row based on 40-in. rows	Rate per 1,000 ft. of row regardless of row width
*Aastar	1 lb.	8 oz.
Broot 15GX	1 lb.	8 oz.
*Counter 15G	1 lb.	8 oz.
*Dyfonate 20G	1 lb.	6 oz.
*Furadan 15G	1 lb.	8 oz.
Lorsban 15G	1 lb.	8 oz.
*Mocap 15G	1 lb.	8 oz.
*Thimet 20G	1 lb.	6 oz.

*A restricted-use pesticide.

Table 4. Labeled uses of rootworm insecticides on corn.

Insecticide	Harvest interval (days)	Popcorn	Sweetcorn	Silage
Aastar	60	No	No	Yes
Broot	90	Yes	No	Yes
Counter	—	Yes	Yes	Yes
Dyfonate	45	Yes	Yes	Yes
Furadan	—	No	No	Yes
Lorsban	—	Yes	Yes	Yes
Mocap	—	No	Yes	Yes
Thimet	30	No	Yes	Yes

Treatment of Corn Following Soybeans

Rootworm beetles are pollen feeders and are attracted to plants other than corn in search of food. Weedy oat and wheat stubble and soybean and hay fields may attract beetles for feeding and subsequent egg laying. In almost all cases, not enough eggs will be laid in soybean fields to cause economically significant populations of rootworms if the field is corn the following year. Treating corn following soybeans for rootworms only results in an unnecessary $8 to $12 per acre expense. Farmers should determine their need for possible treatments on first-year corn by watching the previous year for high beetle populations and assessing the number of weeds or volunteer corn in their soybeans. You should not rely on general claims of probable need, possible increased yield, and "insurance treatment" claims often observed in advertisements.

Extended Diapause

For many years occasional, isolated fields of first-year corn have been damaged by corn rootworms. Such damage has usually been attributed to northern corn rootworms laying eggs in a nonhost crop the preceding year. In 1985, for the first time, damage was more widespread, occurring in a number of widely separated localities in central and western Iowa. It now appears that a portion of the northern corn rootworm population has adapted to a corn-soybean rotation by exhibiting a two-year life cycle. In localities where beetles with the two-year (extended diapause) life cycle constitute a sizable portion of the population, it may be necessary to protect corn following a single season of nonhost crop with a rootworm insecticide. Producers who suspect extended diapause should contact their county extension office and refer to publication IC-451, *Extended Diapause in Northern Corn Rootworm,* for latest recommendations.

Larval Control

Insecticide at Planting

Our present knowledge requires us to recommend that a rootworm insecticide be applied at planting on all fields of corn following corn with one exception. The exception is that if beetle monitoring indicates that insecticide treatment is not needed (see Monitoring Corn Rootworm Beetles section).

All the insecticides recommended in table 3 have performed adequately in experimental plots during the past five years. Also, all the recommended insecticides have failed under certain conditions in experimental plots. None of the materials will kill all of the larvae. A check area of several untreated rows should always be left in each field whenever a rootworm insecticide is used. Check rows allow insecticide performance to be properly evaluated. A suspected insecticide failure cannot be proven without untreated rows.

Insecticides must be applied at recommended rates, placed properly, and incorporated in the top inch of soil. Proper insecticide application should protect a zone of the roots that will support the plant and provide the plant with water and nutrients.

Calibrate equipment often. Experience has shown that flowability of granules alters with changes in humidity. Poor protection of corn roots results when dosage is below the recommended rate by as little as 0.1 to 0.3 pound of actual insecticide per acre.

Most rootworm insecticides are applied as granules placed in a 7-inch band just ahead of the press wheel. Banded applications usually will give better rootworm control than in-furrow treatments with the same product.

The press wheel incorporates or covers the insecticide. If the seedbed is not mellow, covering knives or chains will be needed to adequately cover the insecticide. Crosswinds at planting may blow the granules off the row and prevent effective control. Plastic "windshields" should be used to prevent this from happening.

Liquid formulations of Furadan, Dyfonate, and Lorsban are available and may be applied at the same rate as granules. The liquids also must be covered with soil. In addition, the liquids may be mixed with liquid fertilizer and applied as a double band on each side of the row. Compatability of the insecticide-fertilizer should be checked before mixing. Research data have shown that liquid insecticide-fertilizer treatments give less consistent control than banded granular treatments.

Cultivator Applications

All the granular insecticides listed in table 3 also may be applied as a cultivator application. Treatments should be applied by June 15. Soil must be thrown to cover the granules. Iowa weather may not cooperate with cultivator applications. In some years, continuous wet weather may prevent cultivation and insecticide applications. Poor control also will occur during extremely dry conditions.

Insecticide Performance and Rotation

During the past several years, scientists have gathered an increasing amount of data indicating that enhanced microbial degradation can occur with a number of pesticides, including both carbamate and organophosphate insecticides. In most instances where enhanced microbial degradation has been implicated in poor rootworm control, continuous use of the same insecticide was a primary factor. It is now commonly believed that the continuous use of a pesticide increases the speed with which microbes in the soil reduce that product to a nontoxic form.

Available data indicate that interactions among pesticides used, either concurrently or successively in the same field, may exist at several levels. However, not enough is known for us to recommend a specific use pattern for rootworm insecticides. In the absence of such data we recommend that growers wishing to avoid enhanced microbial degradation in continuous corn should:

1. Switch rootworm insecticides frequently,

2. Not use a carbamate insecticide in successive years in the same field, and

3. Not use a carbamate insecticide in fields where a carbamate has performed poorly in the past.

Adult Control

To Prevent Silk Clipping

Adult beetle control is recommended if beetle feeding prevents the silks from emerging. The number of beetles required to prevent pollination from occurring will depend on the rate at which the silks are growing. Excessive heat and moisture stress will retard silk growth. Under these conditions, 5 beetles per plant may be enough to interfere with pollination. Under normal or nonstress conditions, as many as 15 or more beetles per plant may be required before pollination is diminished. If pollination has not been completed and conditions are such that the beetles are keeping the silks cut, make a single application of 0.5 pound diazinon, 0.5 pound Imidan, 1 pound malathion, 0.1 to 0.2 pound Ambush/Pounce, 0.1 to 0.2 pound Pydrin, or 1 pound Sevin (all listed as actual insecticide per acre). In addition, commercial applicators may use Di-Syston, ethyl or methyl parathion, or malathion ULV according to label directions.

Late-planted or replanted corn will more likely be pollinating later and therefore will be more attractive to migrating beetles. These fields should be watched closely.

Secondary Insect Control

Rootworm insecticides applied as a banded treatment at the labeled rate do not provide broad-spectrum insect control. First-generation European corn borers, for example, are not controlled by rootworm insecticides at labeled rates for rootworms. Light to moderate black cutworm infestations are controlled by Lorsban. Aastar, Counter, Dyfonate, Furadan, and Mocap aid in the suppression of light cutworm infestations. Some insects such as billbugs, white grubs, and sod webworms will more likely be suppressed with an in-furrow treatment rather than a 7-inch band treatment. Also, application rates for control of secondary pests (see label) may be greater than the labeled rate for corn rootworms.

You should carefully determine the major insect pest to be controlled and select the insecticide, rate, and method of application that will best control that pest. Do not rely on any one product to control all insect pests.

Table 5. Oral and dermal toxicities of rootworm insecticides expressed in LD_{50} values.[1]

Insecticide	Acute oral[2]	Acute dermal[2]	Signal word
Aastar	1	2	Danger
Broot	566	2,000	Caution
Counter	4	25	Danger
Dyfonate	8	147	Danger
Furadan	8	>10,200	Warning
Lorsban	97	2,000	Caution
Mocap	61	26	Warning
Thimet	1	2	Danger

[1] LD_{50} refers to the amount of insecticide required to kill 50 percent of a laboratory test animal population.
[2] The lower the number, the more toxic the insectide.

Safety

All insecticides are toxic, but the toxicity of most of the rootworm insecticides is so great that extreme caution should be given to all of the materials (table 5). Only a few particles inhaled or taken orally are enough to cause acute sickness or even death. Just a few grains on the fingers and the subsequent smoking of a cigarette or eating a sandwich would be enough to cause problems.

Many insecticidal exposures and subsequent sicknesses take place during calibration or after the planting is completed and the planter is being prepared for storage. Respect these materials. They are designed to help you produce corn, but they are also designed to kill.

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