Western Corn Belt Corn Rootworm Management Guide

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Management of corn rootworm (CRW) in the western Corn Belt has been a challenge for several decades. These devastating pests have been coined the "billion dollar pest" due to the large economic losses that they can cause as well as the large monetary investment required for annual control. The irrigated, continuous corn cropping system commonly used in this region also compounds the intensity of these pests and makes it more challenging to maintain consistent and effective control. This guide is designed to help understand the basic biology of corn rootworm and make appropriate management decisions regarding one of the more destructive corn pests of the western Corn Belt.

Life Cycle

Western corn rootworm (*Diabrotica virgifera virgifera*) are the predominate species found in the western corn belt, although northern corn rootworm (*Diabrotica barbari*) and southern corn rootworm (*Diabrotica undecipunctata howardi*) can also be found. Western corn rootworm (WCRW) and northern corn rootworm (NCRW) follow very similar life cycles. They both complete one generation per year and have four developmental stages; egg, larvae, pupa and adult. Eggs, which are yellowish and oval shaped, overwinter in the soil and tend to hatch in late May to mid-June and produce larvae. Egg hatching and larvae development is dependent on soil temperature. There are three larval stages that are commonly referred to as instar stages. Each instar stage lasts 7 to 10 days and larvae increase in size throughout this time period. Larvae are bright white in appearance with a brown head capsule during the first instar stage and are typically 1/8" in length. Second instar larvae are 1/4" in length and have more of a creamy white appearance. Third instar larvae are approximately 1/2" in length and are more yellowish in color with a dark brown or black head capsule (Figure 1). Feeding on corn roots occurs during these three instar larval stages and can lower yield potential by decreasing the amount of root mass used to extract water and nutrients for the corn plant (Figure 2). This reduction in root mass can also increase the risk of root lodging (Figure 3). Most often if lodging occurs the plant will attempt to make itself grow upright, this is commonly known as "goose-necking" (Figure 4). Additionally, injured roots are an easily accessible site for bacteria and fungi to enter the plant and predispose the plant to stalk and root rots. After the 3rd instar stage, larvae enter a pupa stage where they pupate in the soil for 6 to 13 days. Adult emergence begins in early July with peak emergence occurring around the beginning of August. The adult stage of CRW is a beetle. WCRW adults are yellow to

Figure 1.► Two 3rd instar corn rootworm larvae.

◄Figure 2. A root pruned by corn rootworm larval feeding (left) and a healthy root (right).

Figure 3. ► Lodged corn due to corn rootworm root damage.

Figure 4. ▲ Goose-necking in corn.

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light green with a black stripe along the sides of their wing covers and are about 5/16" long (Figure 5). Male wing covers are darker in pigmentation than that of the female, which usually has a more striped appearance. Variations in these color patterns may occur. NCRW are generally a tan color (Figure 6). Adult beetles feed on corn leaves, pollen, and soft kernels, but cause the most damage when feeding on non-pollinated or green silks. Female beetles lay their eggs in the top 4-8 inches of the soil during the later part of August into September. A female beetle typically deposits about 80 eggs in the soil at any one time and can lay 500 to 1000 eggs over the span of several weeks.

Scouting-Larval Stage

In season monitoring on a weekly basis throughout the larval stages is important, regardless of which control strategy is used to manage WCRM. This is especially important where high numbers of adult beetles were present the prior year without any control. Even if corn products containing a *B.t* technology with CRW control were planted these acres need to be monitored. Current *B.t.* technologies that control CRW can possibly be overwhelmed by larval populations that are too high.

Larval scouting should begin soon after CRW egg hatch and continue weekly throughout the larval life cycle. Iowa State University indicates approximately 50 percent of larval hatch occurs when 684-767 growing degree days (GDD) have accumulated, using a base 52° F soil temperature at a 4" depth[1]. Other methods used to help estimate timing of CRW egg hatch include calendar date, cotton shed from cottonwood trees, and emergence of lightning bugs. Since root damage cannot be seen below ground it is important to dig roots and assess the current CRW larvae activity. When conducting root digs make sure that an adequate number of sampling areas are tested throughout a given field. Your local agronomist recommends sampling no less than five different areas on a 130 acre pivot. In each of those sampling areas 3-5 plants should be dug, washed, and the roots evaluated for feeding damage. To evaluate CRW feeding, dig an area of soil approximately 6 inches away from the base of each plant to collect the full root system. Carefully examine the soil as you clean the soil from each "root ball". During this time look for presence of larvae and keep count of how many are present as well as their larval stage (instar).

◄Figure 5. Western corn rootworm (WCRW) beetle or adult.

Figure 6.► Northern corn rootworm (NCRW) beetle or adult .

The next step is to evaluate the amount of feeding on the roots. It is not uncommon to find small brown lesions or scarring on the roots if CRW are present. Depending on the size of the lesion, the roots can sometimes be broken open and lateral tunneling can be viewed up or down the root. More intensive feeding often results in root pruning. Root pruning takes place when enough feeding has occurred to shorten the root. The Iowa State University Node Injury Scale (NIS) can be used to evaluate the amount of feeding that has taken place to the root system (Table 1). A root node is one of three or more circles of individual roots that encompass the corn root. Evaluate three nodes per plant starting with the uppermost node which has all of the roots at least 1.5 inches into the soil. While rating, roots should carefully be pulled back at each node to allow for easier inspection of CRW scarring and root pruning on the underlying node.

Based on the experience of your local agronomists in the western Corn Belt, not all WCRW hatch at the same time and it is not uncommon to observe multiple instar larval stages feeding at the same time and in the same field. Consequently, beetles may be emerging above ground while below ground evaluations reveal larvae still feeding on corn roots. This situation is often referred to as extended hatch and should not be confused with extended diapause. Due to their extended hatch period, WCRW may sometimes out live control measures such as at-planting insecticide treatments or *B.t.* technology with CRW traits because of late-season feeding on corn roots. When this occurs the WCRW are able to reproduce and lay eggs that will hatch and feed on the next year's corn crop. Often, this does not mean that the control method has failed, but does explain why beetle numbers can be high even if the corn roots were protected.

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Larval Rescue Control Decisions

Based on observations by area agronomists in the western Corn Belt, a rescue insecticide may occasionally be warranted in addition to the at-planting insecticide treatment or *B.t.* CRW technology. This can be a hard decision to make and evaluating the roots for CRW damage will determine if corrective measures need to be taken. Your local agronomist believes that economic damage is likely to occur when NIS ratings of 0.75 or greater occur under good growing conditions (Table 1). Root damage may change as the season progresses depending on the density and growth stage of the larvae. Therefore, it is important to document the number of larvae that are present per plant along with the larval growth stage (instar). If there are large numbers of larvae and/or they are at a relatively young age (1st to 2nd instar) the likelihood of more feeding should be expected. In contrast, if the larvae are in the 3rd instar stage and the larvae counts are relatively low (average of 2 to 3 larvae per plant) it is likely that much of the root feeding has already occurred as these mature larvae will likely pupate within 7 days.

The current CRW larvae insecticide rescue options are limited to chemigation applications. Lorsban® or Chlorpyrifos® 4E at 2 pints per acre, Cobalt™ at 42 oz/A, or Brigade® at 6.4 oz/A are recommended with at least 1" of irrigation water to move product down into the root zone for effective control. These insecticides bind tightly to soil particles and require larger volumes of water to move them into the corn root zone. Refer to the label of the respective insecticides for complete application instructions.

Unfortunately if chemigation is not a possibility, there are no insecticide options that are currently labeled for use through airplane or ground rig application that will control CRW larvae. The best recourse in this situation is to let the CRW larvae pupate then spray the adult beetles which will be discussed in detail in the next section.

Table 1. Examples of NIS ratings and their descriptions

NIS Rating	Root Injury Description
0.01	No visible root injury
0.05	Root scarring
0.08	Severe root scarring or root tips pruned beyond 1.5 inches of crown
0.10	10% of a node pruned (often 1 root) within 1.5 inches of crown
0.25	25% of a node pruned within 1.5 inches of crown
0.75	75% of a node pruned within 1.5 inches of crown
1.0	A full node pruned within 1.5 inches of crown
1.5	One full node and 50% of another node pruned within 1.5 inches of the crown
2.0	Two full nodes pruned within 1.5 inches of crown
3.0	Three full nodes pruned within 1.5 inches of crown (maximum value)

Source: [3]James D. Olsen et al. Journal of Economic Entomology

Managing Corn Rootworm Adults in High Pressure Areas

Corn is a profitable crop on most irrigated acres in the western Corn Belt and as a result many irrigated fields have been planted to continuous corn for many years. Typically, continuous corn fields have the highest CRW populations, however; not all continuous corn fields reach economic infestations of CRW. Growers in these areas rely on *B.t.* technology with the CRW protection trait, at-planting insecticides, high dose insecticide seed treatments and/or CRW adult control programs to protect them from CRW feeding. In many of these areas, CRW pressure is heavy and extended hatches are common with WCRW. To aid in the effectiveness of any of the aforementioned CRW control strategies, treating CRW beetles is part of an integrated pest management program used to reduce the CRW population for the next season's corn crop.

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Traditionally, CRW beetle scouting has been used to determine the need for insecticides the next year if a field is to be planted back to corn. Beetle scouting can also help establish where *B.t.* technology, with activity against CRW, would be most valuable the following year. Finally, in high pressure CRW areas, beetle counts can be used to judge if a rescue insecticide spray may be needed to prevent yield decreases due to CRW silk clipping or to lower the CRW population for next year's crop.

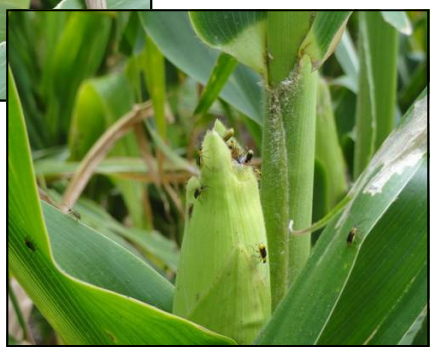
Unfortunately, the time frame for controlling CRW adults to prevent egg laying and controlling adults to prevent silk clipping do not overlap. The majority of corn rootworm eggs are laid after the time when treatments to prevent silk clipping would be necessary.

Adult beetles begin to emerge from corn fields in July. The CRW beetles feed primarily on pollen, green silks or leaves in corn fields. Since CRW beetles search for green silks to feed on, the earliest silking corn fields in an area may have the most silk clipping.

Start scouting for CRW beetles soon after beetle emergence begins and continue scouting weekly until threshold levels are exceeded or beetle activity stops[2]. The University of Nebraska–Lincoln recommends examining 50 plants per field and taking samples from each quarter of the field. Make sure the sampled plants are several paces apart so that examining one plant does not drive beetles off of the next plant that will be sampled[2]. The most reliable method is to examine the whole plant for beetles. It is important to thoroughly look over the plant since CRW beetles can hide behind leaf sheaths or in the silks. Another method is to look for beetles only in the ear zone (the area including the upper surface of the leaf below the primary ear and the under surface of the leaf above the primary ear).

◀Figure 7. A corn ear with tassels eaten by many WCRW.

Figure 8. ▼ Several WCRW on a corn plant.



Rescue Insecticide-Silk Clipping

Densities of at least five adults per plant typically are required to affect pollination in commercial cornfields[2]. Fields at the greatest risk for economic loss due to silk clipping are seed-production fields. The University of Nebraska-Lincoln recommends observing the number of adults per plant as well as the amount of silk tissue extending from the ear tips. When 1/2 to 1 inch of fresh silk remains and soil moisture is adequate, successful pollination is likely to occur. However, severe silk feeding at 25-50% pollen shed may indicate a need to apply insecticide, especially in seed -production fields[2]. Many insecticides are labeled as rescue treatments to prevent excessive silk clipping.

Lowering Next Year's Population

The University of Nebraska believes if CRW beetle counts exceed 0.75 beetles per plant in continuous corn, damaging populations of CRW are possible in that field the next year (Figures 7 and 8)[2]. In first year corn, there is a higher proportion of female beetles; consequently, the threshold is lowered to 0.56 beetle per plant[2]. Those thresholds are based on a 24,000 plant population per acre. Thresholds for number of beetles per plant at different plant populations has been calculated in Table 2. If the ear zone scouting method is used, divide the thresholds in half, since approximately 50% of the beetles per plant are counted with this method.

If fields have CRW beetle counts over the threshold consider the following options: rotating out of corn, planting *B.t.* corn technology with CRW control, using an insecticide at planting, or cultivation to prevent decreases in yield potential due to CRW feeding. The University of Nebraska-Lincoln indicates that fields which do not reach an economic threshold throughout the beetle egg-laying period are not expected to have economic populations of CRW the following year.

If using a rescue treatment to reduce CRW beetle populations, time the spray when the beetle threshold has been exceeded and 10% of the female beetles are gravid (abdomen visibly distended with eggs). This is important because the majority of the first beetles to emerge are male, and females require at least 10-14 days of feeding before they can lay eggs[2].

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If applied too early, females emerge after the insecticide spray is no longer effective; therefore, allowing much of the CRW beetles to survive and lay eggs.

After treating for CRW beetles, monitor fields weekly. If beetle numbers exceed 0.5 beetles per plant, retreatment is warranted[2]. Late maturing fields are particularly susceptible to CRWs moving in from close, earlier maturing fields.

Table 2. Average number of western corn rootworm beetles present in cornfields that may produce an economically damaging rootworm population in corn the following year.

Plants per acre	Average number of rootworm beetles			
	Continuous corn[a]		First year corn[b,c]	
	Per plant	Per ear zone	Per plant	Per ear zone
14,000	1.28	0.64	0.96	0.48
16,000	1.12	0.6	0.84	0.42
18,000	1.00	0.5	0.75	0.37
20,000	0.9	0.45	0.68	0.34
22,000	0.81	0.4	0.61	0.3
24,000	0.75	0.37	0.56	0.28
26,000	0.69	0.34	0.52	0.26
28,000	0.64	0.32	0.48	0.24
30,000	0.6	0.3	0.45	0.23
32,000	0.56	0.28	0.42	0.21

Source: [2]B. Wright, University of Nebraska-Lincoln

[a] Based on a 50:50 ratio of females to males.

[b] Based on a 70:30 ratio of females to males.

[c] Use this threshold for continuous corn fields that did not have larval populations earlier in the season (adult beetles are immigrants, similar to first year corn). During late July and August these beetles will lay eggs in corn fields. These eggs overwinter in the soil, hatch into CRW in the spring, and feed on corn roots if continuous corn is grown. Not all continuous corn fields have economic infestations of CRW.

Sources:

[1] *E. Hodgson and A. Sisson. June 23, 2011. Predicted corn rootworm egg hatch approaching. Integrated Crop Management News. Iowa State University Extension.*

[2] *B. Wright. July 24, 2009. Use of corn rootworm scouting numbers as basis for 2010 production decisions. Crop Watch. University of Nebraska-Lincoln.*

[3] *J. D. Oleson et al. 2005. Node-Injury Scale to evaluate root Injury by corn rootworms (Coleoptera: Chrysomelidae). Journal of Economic Entomology. 98 (1) 1-8.*

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Individual results may vary, and performance may vary from location to location and from year to year. This result may not be an indicator of results you may obtain as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible.