Northern and Western Corn Rootworm in South Dakota

Adam J. Varenhorst, Assistant Professor and SDSU Extension Field Crop Entomologist
Mike W. Dunbar, former SDSU Postdoctoral Research Associate
Patrick Wagner, SDSU Extension Entomology Field Specialist
Philip Rozeboom, SDSU Extension Integrated Pest Management Coordinator
Amanda Bachmann, SDSU Extension Pesticide Education Coordinator
Bradley McManus, Research Associate, SDSU
Billy Fuller, Professor of Entomology, SDSU

July 2021

Introduction

Northern corn rootworm (NCR), *Diabrotica barberi* Smith & Lawrence, and western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, are major pests of corn throughout North America. Populations of both species are common in South Dakota. The adults can be readily found in cornfields from July through the first fall frost. However, the greatest economic losses are associated with larvae feeding on corn roots, which begins in early June and continues until adult emergence.

Biology of Corn Rootworm

Description. Adult NCR (Fig. 1) are typically one solid color which can range from light to dark green. Occasionally tan to yellow adult NCR can be observed. These individuals are newly emerged (often referred to as teneral[1]) and will acquire color upon feeding. Typically, adult WCR (Fig. 2) are slightly larger than NCR (Fig. 3) and are yellow in color with three dark stripes running lengthwise on their hardened forewings or elytra[1]. The stripes on adult WCR can vary from three distinct lines to one large stripe covering most of the forewings. Unlike WCR, adult NCR do not have markings on their hardened forewings.

Figure 1. Color variations of adult northern corn rootworm. Photo courtesy of Adam Varenhorst.

Figure 2. Variation of adult western corn rootworm. Lines present on the elytra (hardened wings covering the abdomen) can vary among adults. Photo courtesy of Adam Varenhorst.

Figure 3. Adult western corn rootworm (right) and adult northern corn rootworm (left). Western corn rootworms are generally larger in size than northern corn rootworm. Photo courtesy of Adam Varenhorst.

Corn rootworm larvae are wormlike and are very difficult to differentiate between species (Fig. 4). Larval bodies are pale yellow or white with brown head capsules and a black plate on the bottom of the tip of their abdomen. Larvae have three pairs of legs, but unlike caterpillar larvae, corn rootworm larvae do not have prolegs present on their abdomen.

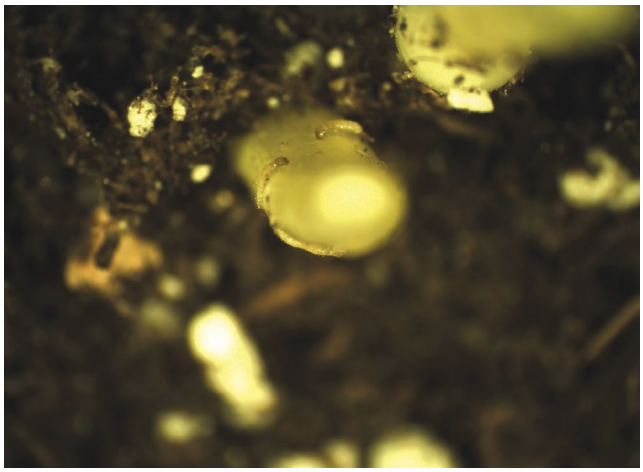

Figure 4. Corn rootworm larvae feeding on a corn root. Photo courtesy of Mike Dunbar.

Lifecycle. The lifecycles of NCR and WCR are very similar. Both species have a single generation per year (Fig. 5). Adults emerge from the soil in mid-summer and feed on corn pollen, silks, and tassels. Beetles mate rapidly after emerging. Although mated females lay eggs in cornfields, adult beetles, especially NCR, are readily found in other crops. Eggs overwinter in the soil and hatch early the following spring. Rootworm larvae feed almost exclusively on corn roots, so larvae will starve if they hatch in fields planted to another crop. There is some evidence that rootworm larvae may feed on the roots of grassy weeds; however, these are not optimal hosts for them. Pupation occurs in the soil and is quickly followed by adult beetle emergence.

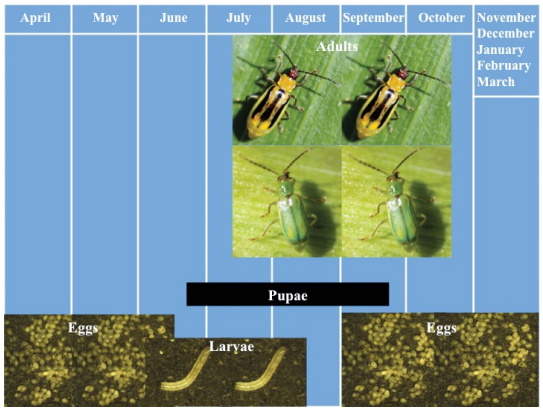

Figure 5. Corn rootworm lifecycle.

There are notable exceptions to corn rootworm lifecycles that may affect pest-management decision making. Some populations of NCR can survive as eggs in the soil for multiple years. This characteristic is referred to as “extended diapause” and is an adaptation to crop rotation. These populations of NCR are referred to as being rotation-resistant and are present in South Dakota. Populations of WCR have also developed resistance to crop rotation, but in a different manner. For normal WCR, females lay eggs in cornfields. However, rotation-resistant WCR females also deposit eggs in fields containing other crops. This resistance mechanism to crop rotation is commonly referred to as the “soybean variant.” The rotation-resistant WCR will lay eggs in corn, soybean, oats, alfalfa and winter wheat. At present, rotation-resistant WCR are not found in South Dakota.

Injury to Corn

Yield loss associated with corn rootworms is mainly caused by larval feeding on corn roots. Roots that are injured by larval feeding take up less nutrients and water, which leads to reduced yields. Additionally, injured corn roots are weaker and are more prone to injury from wind, which may result in goose necking (Fig. 6) or lodging (Fig. 7). If an entire root node is injured by rootworm larvae feeding, corn yields are reduced by an average of 15 to 17%. Although economic losses due to adult feeding occur infrequently, adult rootworms can reduce pollination and ear fill by consuming pollen and silks (Fig. 8).

Figure 6. Goose-necked corn plant caused by rootworm larval feeding on corn roots. Photo courtesy of Mike Dunbar.

Figure 7. Severely lodged corn as a result of corn rootworm larval feeding on corn roots. Photo courtesy of Mike Dunbar.

Figure 8. Silks clipped from corn ear by adult corn rootworm. Photo courtesy of Mike Dunbar.

Management Options

There are several options for corn rootworm management. The first option is crop rotation, which is effective because larvae that hatch from eggs laid in cornfields the year prior will starve in fields rotated away from corn. However, extended diapause populations of NCR are present in South Dakota and crop rotation will not be effective unless a three year or greater crop rotation is utilized. Farmers planting first-year corn should consider previous field history in terms of rootworm pressure to guide their management decisions.

There are several conventional insecticides labeled for management of both larvae and adult corn rootworm. Soil-applied insecticides used during planting effectively protect corn roots and yield from larval feeding. Although soil-applied insecticides protect corn roots, many larvae still survive to adulthood. Foliar-applied insecticides are typically used to reduce silk feeding by adults or suppress adult populations and egg laying. Applying a foliar insecticide is warranted if adult rootworm populations are large and corn silks are still green. If adult rootworms are present and silks are clipped to less than ½ inch, insecticides should be applied; if silks are brown or greater than ½ inch in length then an insecticide treatment is not necessary. Using foliar-applied insecticides to reduce adult populations or egg laying has variable results as rootworm from surrounding cornfields may invade a previously sprayed field. For a list of insecticides that are currently labeled for in-furrow application and foliar application please refer to the current edition of the South Dakota Pest Management Guide: Corn.

Another option for management of rootworm is Bt corn, which produces insecticidal toxins that target developing larvae. However, Bt toxins have no effect on adult rootworm. There are currently four Bt toxins available that target rootworm larvae, which are available in Bt corn either singularly or in pyramids[1] of multiple toxins (Cry3Bb1, Cry34/35Ab1, mCry3A and eCry3.1Ab). Although Bt corn is still effective for management of rootworm larvae in much of the Corn Belt, several cases of Bt-resistant WCR have been reported. Populations of Cry3Bb1- and mCry3A-resistant WCR have been found in Illinois, Iowa, Nebraska, and North Dakota. Cross-resistance[1] between Cry3Bb1 and mCry3A toxins has also been observed in the field. Additionally, laboratory studies have demonstrated that cross-resistance also exists among eCry3.1Ab and both Cry3Bb1 and mCry3A Bt toxins (e.g., resistance to one of the toxins relates to resistance to another). In North Dakota, populations of NCR were detected that are resistant to corn hybrids expressing Cry3Bb1 and Cry34/35Ab1. To date, no documented cases of Bt-resistant WCR or NCR populations have been reported in South Dakota.

Planting histories of fields where Bt resistance was initially found showed a pattern of planting continuous corn for several years, together with management of rootworm consisting almost exclusively of Bt corn that produced a single Bt toxin. Pyramided corn producing two Bt toxins can help delay resistance or mitigate the risk of injury from resistant populations. However, because the threat of cross-resistance exists, Bt toxins within pyramids should not consist of combinations of Cry3Bb1, Cry34/35Ab1, or eCry3.1Ab toxins. Combining Bt corn with soil-applied insecticides is also not advised for multiple reasons. First, using both Bt corn and soil-applied insecticides is costly. Second, one key benefit of pyramiding multiple types of insecticides together is that insect resistance is delayed longer compared to when insecticides are used individually. Unfortunately, combining Bt corn with soil-applied insecticides has been shown to increase selection pressure on rootworm to adapt to Bt corn due to alterations in emergence of susceptible and resistant individuals in a cornfield.

Evaluating Management Success

A method for checking the effectiveness of a current rootworm management is to rate corn roots for rootworm feeding injury. To rate roots, soil from corn roots dug from a cornfield during July or August is removed and rootworm feeding is evaluated on the 0 to 3 node-injury scale (Fig. 9). A score of one in the node-injury scale is equivalent of a single complete root node injured by larval feeding and can reduce yields by 15 to 17% for each node of corn root injured. Economic loss from larval feeding injury can begin at 0.25, depending on the price of corn and the cost of management. Although root rating is effective at assessing management tactics used against corn rootworm, there are no remediation treatments available to reduce yield losses if significant feeding has occurred.

Figure 9. Examples of root injury as scored by the node-injury scale. Photos and graphical concept courtesy of Chris DiFonzo, Michigan State University.

Photo	Node-injury Scale
	**Node-injury Scale: 0.00** *No apparent feeding*
	**Node-injury Scale: 0.1-0.9** *One to nine roots pruned (less than a full node)* **Symptoms:** May notice some lodging **Yield Impact:** Some economic loss could occur at or above a 0.5 rating, especially under dry (water-stressed) conditions.
	**Node-injury Scale: 1.0-1.9** *At least one full node destroyed to within 1.5 inches of stalk* **Symptoms:** Some lodging and goosenecking. **Yield Impact:** Probably an economic loss in grain or silage, unless conditions are favorable for regrowth and lodging is minimal. Note that regrowth can obscure damage, so care must be taken when rating roots later in the season.
	**Node-injury Scale: 2.0-2.9** (For Bt corn this level of feeding is a sign of resistance) *Two or more nodes destroyed* **Symptoms:** Severe lodging and goosenecking. Beetles may be present and feeding on the silks and leaves. **Yield Impact:** Economic impact with loss in grain. Expected to have poor ear fill if silks are fed on. Difficulty in harvesting for both grain and silage.
	**Node-injury Scale: 3.0** (For Bt corn this level of feeding is a sign of resistance) *Two or more nodes gone* **Symptoms:** Severe lodging & goosenecking. Numerous beetles may be present, feeding on leaves and silks. **Yield Impact:** Severe. Loss in grain, in addition to poor ear fill, if silks are fedon. Difficulty in harvesting both grain and silage.

Scouting

Scouting for adult rootworm with yellow sticky cards throughout August can help assess the risk of injury to corn planted within the same field the following year. Yellow sticky cards (approximately $2.58 per card) are covered with a sticky glue-like substance, and adult rootworm that are attracted by the yellow coloring of the card become trapped. If average captures of adult rootworm exceed two rootworms per trap per day during any sampled week, economic thresholds have been exceeded and rootworm management is advised for the following year if corn is to be planted.

Acknowledgements

This publication was developed through funding from South Dakota State University Extension and the National Institute of Food and Agriculture, Crop Protection and Pest Management Applied Research and Development Program support through grant 2017-04417.

References

Calles-Torrez, V., J. J. Knodel, M. A. Boetel, B. W. French, B. W. Fuller, and J. K. Ransom. 2019. J. Econ. Entomol. 112: 1875-1886.

Gassmann, A. J., J. L. Petzold-Maxwell, E. H. Clifton, M. W. Dunbar, A. M. Hoffmann, D. A. Ingber, and R. S. Keweshan. 2014. Field-evolved resistance by western corn rootworm to multiple Bacillus thuringiensis toxins in transgenic maize. PNAS. 111: 5141-5146.

Gray, M. E., T. W. Sappington, N. J. Miller, J. Moeser, and M. O. Bohn. 2009. Adaptation and invasiveness of western corn rootworm: intensifying research on a worsening pest. Annu. Rev. Entomol. 54: 303-321.

Krysan, J. L., J. J. Jackson, and A. C. Lew. 1984. Field termination of egg diapause in Diabrotica with new evidence of extended diapause in D. barberi (Coleoptera: Chrysomelidae). Environ. Entomol. 13: 1237-1240.

Levine, E., and H. Oloumi-Sadeghi. 1991. Management of diabroticite rootworms in corn. Annu. Rev. Entomol. 36: 229-255.

Olson, J. D., Y. Park, T. M. Nowatzki, and J. J. Tollefson. 2005. Node-injury scale to evaluate root injury by corn rootworms (Coleoptera: Chyrsomelidae). J. Econ. Entomol. 98: 1-51.

Petzold-Maxwell, J. L., L. J. Meinke, M. E. Gray, R. E. Estes, and A. J. Gassmann. 2013. Effect of Bt maize and soil insecticides on yield, injury, and rootworm survival: implications for resistance management. J. Econ. Entomol. 106: 1941-1951.

[1]Entomological or Related Terms

Teneral - The state of an insect immediately succeeding molting, during which the insect's exoskeleton has not hardened.

Elytra - A modified, hardened forewing that covers a pair of wings used for flight. Elytra are characteristic of beetles.

Cross-resistance - Cross-resistance occurs when resistance to one toxin confers resistance to a different toxin without previous exposure to that different toxin.

Pyramids - Combinations of multiple pesticides that each target the same pest species.

South Dakota State University Extension

SOUTH DAKOTA STATE UNIVERSITY®
AGRONOMY, HORTICULTURE AND PLANT SCIENCE DEPARTMENT

P-00209