SDSU Extension

iGrow Corn

BEST MANAGEMENT PRACTICES

Chapter: 51
Corn Insect Pests

Adam J. Varenhorst (Adam.Varenhorst@sdstate.edu), Mike W. Dunbar (Michael.Dunbar@sdstate.edu), Billy Fuller (Billy.Fuller@sdstate.edu), and Wade French (Wade.French@ars.usda.gov)

Historically, the major corn insect pests in South Dakota have been northern and western corn rootworm, European corn borer and black cutworm. Bt-corn hybrids are effective against most of these pests. However, there are also minor or sporadic pests of corn in South Dakota including the bird cherry oat aphid, corn leaf aphid, fall armyworm, true armyworm and common stalk borer. Although these pests are considered minor, each is capable of reducing corn yields under the appropriate conditions.

Issues faced: This chapter discusses the biology and management of important corn insect pests commonly observed in South Dakota.

Corn Rootworm

Northern corn rootworm (*Diabrotica barberi*, Smith & Lawrence) and Western corn rootworm (*Diabrotica virgifera virgifera*, LeConte) (Fig. 51.1).

Pest Highlights

- Northern corn rootworm and western corn rootworm can cause economic damage to corn in South Dakota.
- Bt-corn hybrids that target corn rootworm are effective against corn rootworm larvae.
- Crop rotation is an effective tactic in managing corn rootworms.
- Corn rootworm larvae are currently the most damaging insect pests of continuous corn in South Dakota.

Figure 51.1 Color variation of northern (top) and western (bottom) corn rootworm adults. (Courtesy of Adam J. Varenhorst)

Rootworm Description

Adult northern corn rootworm beetles are approximately 1/4-inch long and vary in color from yellow to green (Fig. 51.1 top). Western corn rootworm beetles are slightly larger with a black head and yellow thorax and abdomen. The western corn rootworm adults have three black longitudinal stripes on their hardened forewings. The stripes can vary in size and may appear as three distinct stripes or one broad stripe that covers the majority of the forewings (Fig. 51.1 bottom). The wormlike larvae of both species

(Fig. 51.2) are white with a brown head and grow to approximately 5/8-inch in length. Both the larvae and adults have chewing mouthparts.

Rootworm Biology

Adult corn rootworm beetles feed on corn pollen, silks and leaves. Feeding on the pollen and silks has the potential to reduce pollination and ear fill; however, significant injury from adult feeding occurs infrequently. Adults may also feed on soybean, sunflowers and garden flowers but have not been reported as pests of these crops in South Dakota. Adult female corn rootworms deposit eggs into the soil from late summer into the fall or until the females are killed by the first hard frost (Fig. 51.2). In South Dakota, rootworm eggs are primarily laid in cornfields where they overwinter in the soil. Fields that are planted to corn following corn have an increased chance of being infested with corn rootworm eggs from the previous season. Egg hatch occurs once the corn roots begin to grow. Corn rootworm larvae feed on corn roots in June and July during active root growth. Larvae transform into pupae in mid-July, and adult rootworm beetles emerge from the soil from late July through August (timing will vary due to soil moisture and temperature) and mate rapidly after emerging.

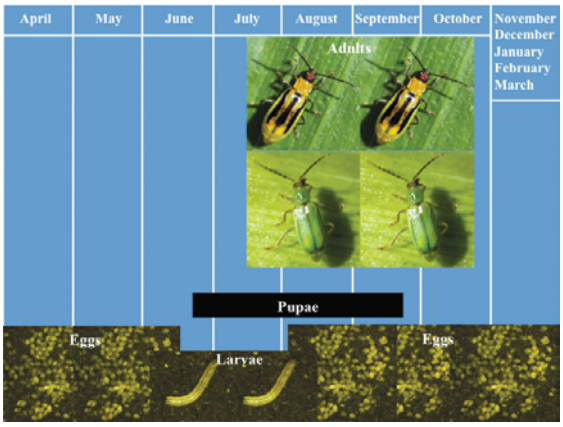

Figure 51.2 Life cycle of the NCR and WCR in South Dakota. (Photos courtesy of Mike W. Dunbar and Adam J. Varenhorst)

Figure 51.3 Goose-necked corn is a symptom of early season corn rootworm larvae feeding on corn roots. (Courtesy of Mike W. Dunbar)

The principal cause of yield losses associated with corn rootworm is larval feeding on corn roots during active root growth. The damage to corn roots reduces water and nutrient uptake, and yield is reduced on average by 15% to 17% for each node of corn root pruned by rootworm larvae. Furthermore, roots weakened by larval feeding can result in goose-necked plants (Fig. 51.3) and lodged corn (Fig. 51.4). Lodged corn is difficult to harvest and decreases harvest efficiency and overall yields (see Chapter 37 for tips on harvesting lodged corn). Typically, larval infestations are clustered within fields, and areas within the field that experienced higher infestation levels in a previous year tend to have higher infestations in the same areas when corn is planted the following year (Ellsbury et al., 1998).

Figure 51.4 Lodged corn is a symptom of corn rootworm larvae feeding on corn roots. (Courtesy of Mike W. Dunbar)

Corn rootworm larvae are generally unsuccessful when feeding on the roots of other crops including soybean, wheat, sunflower and alfalfa. This specialization makes crop rotation an excellent management option. Although multiple species of foxtail (Setarai spp.) grasses including green, yellow and giant can serve as alternative hosts for corn rootworm larvae, the roots of these grasses are a poor nutritional substitute and produce smaller corn rootworm individuals (Ellsbury et al., 2005). Other management options include the use of Bt-corn hybrids that have rootworm-active toxins or in-furrow granular and liquid insecticides.

Management: Bt-corn Hybrids

Many genetically engineered *Bt*-corn hybrids are resistant to corn rootworm larvae (Table 51.1). These *Bt*-corn hybrids produce toxins derived from the soil-dwelling bacterium Bacillus thuringiensis that are toxic to rootworm larvae. Although *Bt* corn reduces rootworm larval feeding injury, adult corn rootworm are not affected by *Bt* toxins. *Bt* corn targeting corn rootworm became commercially available in 2003, and these hybrids produced only one Bt toxin that targeted rootworm. More recently, *Bt*-corn hybrids have become commercially available that produce a pyramid of toxins (two or more toxins) that target corn rootworm. To delay the development of Bt-resistant rootworm, the EPA mandated that *Bt*-corn hybrids must be planted with non-*Bt* corn refuges, which depending on the *Bt* toxin(s) produced, range in size from a 20% block of non-*Bt* corn to 5% refuge-in-the-bag (RIB). However, reports of *Bt*-resistant corn rootworm already have been documented in Iowa, Nebraska and Illinois to Cry3Bb1 and mCry3A *Bt* toxins.

Table 51.1 *Bt*-corn genes that provide resistance to northern and western corn rootworm larvae.

***Bt* toxin(s)**	**Trade name**
Cry3Bb1	YieldGard VT Triple Genuity VT Triple Pro Genuity VT Triple PRO RIB Complete
mCry3A	Agrisure RW Agrisure GT/RW Agrisure CB/LL/RW Agrisure 3000GT Agrisure Artesian 3011A Agrisure Viptera 3111 Agrisure 3122 E-Z Refuge Optimum AcreMax XTreme Optimum TRIsect
Cry34/35Ab1	Herculex RW Herculex XTRA Optimum AcreMax 1 Optimum AcreMax RW Optimum AcreMax Xtra
Cry3Bb1 + Cry34/35Ab1	Genuity SmartStax Genuity SmartStax RIB Complete Refuge Advanced Powered by SmartStax
mCry3A + eCry3.1Ab	Agrisure Duracade 5222 E-Z Refuge
mCry3A + Cry34/35Ab1	Optimum Intrasect XTreme
Cry34/35Ab1 + eCry3.1Ab	Agrisure Duracade 5122 E-Z Refuge

Management: Rootworm T-band/in-furrow Insecticides and Seed Treatments

Many different insecticides are labeled for rootworm larval management (Table 51.2). Granular or liquid insecticides are applied in-furrow or very close to the seed furrow during planting. Alternatively, systemic insecticidal seed treatments are also available to corn growers for the management of corn rootworm larvae (Table 51.2). It is not advised to use a *Bt*-corn hybrid that has more than one toxin targeting corn rootworm in combination with any conventional soil insecticide application. The purpose of this recommendation is to reduce economic inputs and to reduce selection pressure on corn rootworm to adapt to two distinct management tactics.

Table 51.2 Node-Injury Scale scores.

Node-Injury score	**Root Description**
0.00	No feeding injury observed
1.00	One full root node pruned
2.00	Two full root nodes pruned
3.00	Three full root nodes pruned; scale maximum

For a list of T-band/in-furrow insecticides and also insecticide seed treatments that are currently labeled for the management of corn rootworm larvae, please refer to the current edition of the South Dakota Pest Management Guide: Corn.

Management: Crop Rotation

Crop rotation has been an effective management tool against corn rootworm for over a century. Adult rootworm lay eggs in cornfields during August, and larvae that hatch the following spring in fields rotated away from corn starve to death. However, populations of both northern and western corn rootworm have adapted to crop rotation in parts of the corn belt.

Rotation-resistant northern corn rootworm are present in South Dakota. These northern corn rootworm

populations have adapted to crop rotation by having an extended diapause, and are sometimes referred to as "extended-diapause" rootworm. Female rotation-resistant northern corn rootworm still lay eggs in cornfields; however, only a proportion of those eggs hatch the following year while another proportion will hatch two, three or even four years later. Extended crop rotations that do not vary over time (e.g., a three year corn-soybean-wheat rotation repeated again and again) can select for a greater percentage of eggs to hatch during years corn is planted, although this process would take many rotations cycles to build significant northern corn rootworm populations.

Rotation-resistant western corn rootworm are not presently found in South Dakota, these populations are typically found east of the Mississippi River. Rotation-resistant western corn rootworm are commonly called the "soybean variant" rootworm, but this name can be misleading. Western corn rootworm adapted to crop rotation by laying eggs not only in cornfields, but any other crop. The name "soybean variant" emerged because rotation-resistant western corn rootworm first appeared in areas dominated by corn-soybean rotation.

Assessing Management Success through Rating Corn Roots

Rating corn roots for rootworm feeding injury can assess whether rootworm populations have reached economically damaging levels within a field. Rating roots for rootworm feeding injury is additionally advantageous because it measures the effectiveness of any rootworm management strategy that is presently being practiced within a field. However, roots are rated within the planting season and there are no remediation treatments presently available to reduce yield loss if significant feeding has occurred.

To rate corn roots for injury, 10 roots should be dug from random areas within the field during July or August. Use a spade and dig in a circular pattern approximately 4 - 5 inches away from the cornstalk. Remove excess dirt without damaging the corn roots. Soak the sampled roots in water for 24 - 48 hours, and remove any remaining soil using a high-pressure hose. Allow the roots to dry prior to rating.

Corn roots are rated on the 0 - 3 Node-Injury Scale (Olson et al., 2005). Only root nodes 4, 5 and 6 are rated for rootworm feeding injury. The brace roots that emerge from the stalk above the soil line represent node 7, while node 6 roots emerge at the soil line. To begin rating a corn root, count the total number of roots within a node for nodes 4, 5 and 6. For example:

Root sample #1:	Node #4 has 10 roots
	Node #5 has 12 roots
	Node #6 has 10 roots

Re-inspect each of the nodes and determine the number of roots that display rootworm larval feeding injury, typically referred to as "pruned" roots. A root is considered pruned if the root has been eaten back to approximately 1.5 inches from the stalk. In this example:

Root sample #1:	Node #4 has 5 / 10 roots pruned
	Node #5 has 4 / 12 roots pruned
	Node #6 has 2 / 10 roots pruned

Calculate the proportion of pruned roots for each node by dividing the number of pruned roots by the total number of roots. In this example, node #4 has 5 pruned roots out of 10 total roots, so the proportion of pruned roots for node #4 is 0.50. Sum the proportion of pruned roots for nodes 4, 5 and 6 to get the Node-Injury score. In this example, root sample #1 would score:

0.50 (Node #4) + 0.33 (Node #5) + 0.20 (Node #6) = 1.03

Rate all 10 sampled corn roots and then average the Node-Injury score to estimate the amount of root injury within a field. Table 51.2 describes how root injury is scored on the Node-Injury Scale. Depending on the cost of rootworm management and price of corn, economic loss from rootworm larval feeding may

	**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 & 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 fed-on. Difficulty in harvesting both grain and silage.

Figure 51.5 A visual guide of the Node-Injury Scale ratings used to determine the severity of corn rootworm larvae root pruning. (Photos, concept, and information courtesy of Chris DiFonzo, Michigan State University)

begin to occur above average Node-Injury scores of 0.25. For Bt corn that targets corn rootworm, greater than expected injury is said to occur if average Node-Injury scores exceed 1.00 for Bt corn with only a single Bt toxin and 0.50 for Bt corn with a pyramid of Bt toxins.

Scouting and Economic Thresholds

Scouting for adult rootworm during August can help assess the risk of injury to corn planted within a field the following year. A simple method used to scout for adults are yellow sticky cards. These cards are can be

purchased through several retailers, and cost approximately $2 per card. The cards have alternating yellow and white sides, with the yellow side being covered in a gluelike substance. If yellow stick cards are being used to scout for corn rootworm populations, 10 cards should be placed randomly throughout the field in August. The cards are then replaced on a weekly basis (they should not remain in fields longer than 10 days) throughout August. For each card, count the total number of corn rootworm adults on the card and divide this total by the number of days the card was left in the field to calculate the number of rootworm adults captured per day. If averages exceed two or more adults captured per day, the economic threshold has been reached (Dunbar and Gassmann, 2013).

European Corn Borer (*Ostrinia nubilalis*, Hübner)

Pest Highlights

- South Dakota has univoltine (one generation) and bivoltine (two generations) ecotypes.
- *Bt*-corn hybrids with toxins specific to the European corn borer provide effective management.
- Univoltine corn borers can be more damaging and harder to manage than bivoltine corn borers.
- Per-plant yield loss can range from 2% to 6% per larva in the absence of management.

European Corn Borer Description

European corn borer larvae are light tan to pink in color with dark brown spots on each segment of their body. Larvae have a dark brown head capsule, three pairs of true legs and four pairs of abdominal prolegs (Fig. 51.6). Mature larvae range in size from ¾- to 1-inch in length. The female European corn borer moth is approximately ½-inch in length with triangular wings that have yellow to brown wavy markings. The male moths are smaller and tend to be darker in color (Fig. 51.7).

Figure 51.6 A European corn borer larva feeding inside a cornstalk. (Courtesy of Frank Peairs, Colorado State University, Bugwood.org)

European Corn Borer Biology

Within a single generation, European corn borer undergoes four developmental stages/forms: egg, larva, pupa, and adult. During larval development, there are five instars or larval stages. Each subsequent instar undergoes a period of growth followed by a molt (casting off skin). When the larvae reach the fifth and final instar, they pupate and transition from a caterpillar to a moth. Like all insects, the European corn borer life cycle is effected by the climate, resulting in a different number of generation per year occurring in different parts of the state. In northern South Dakota, European corn borer is univoltine (one generation per year). In central and southern South Dakota, European corn borer can be univoltine or bivoltine (two generations per year).

Figure 51.7 Male (left) and female (right) European corn borer moths on a leaf of corn. (Photo courtesy of Adam Sisson, Iowa State University, Bugwood.org)

Univoltine European Corn Borer (one generation per year)

European corn borer populations with only one generation per year are most commonly found in the northern counties of South Dakota. Moths of these populations begin flying in mid-June, with peak populations occurring in mid-July. Seasonal temperatures affect adult emergence, but moths generally lay eggs on the underside of corn leaves from June to July. Eggs hatch within one week. Newly hatched larvae feed on the leaf collars and may migrate toward the tassels to feed on pollen. Young larvae often feed on the leaf surface and midribs, resulting in a "windowpane" type injury that is characterized by the removal of the surface layer of the leaf (Fig. 51.8). Second- and third-instar larvae will feed in the whorl, causing a

"shot hole" type of injury (Fig. 51.9). Fourth-instar larvae tunnel into the stalk, molt into fifth-instar larvae and continue feeding until the end of the growing season. Fifth-instar larvae overwinter in stalk residues left in the field, and transform into pupae and moths in the following spring.

Figure 51.8 "Windowpane" type injury caused by European corn borer larvae feeding on a corn leaf. (Courtesy of Eugene E. Nelson, Bugwood.org)

Figure 51.9 "Shot hole" type injury caused by European corn borer larvae present on a corn leaf. (Courtesy of Frank Peairs, Colorado State University, Bugwood.org)

Bivoltine European Corn Borer (two generations per year)

In southern portions of South Dakota, European corn borer can have up to two generations per year. Adult moths begin flying in mid-May and females lay eggs on the underside of the leaves when corn is between growth stages V6 to V9. Similarly to univoltine populations, newly hatched bivoltine larvae also feed on the leaf surface and midribs, and may cause windowpane damage (Fig. 51.8). Second- and third-instar larvae feed in the whorl, causing a shot hole injury (Fig. 51.9) that is visible when leaves unfurl. Fourth-instar larvae tunnel into the stalk and then molt into fifth-instar larvae approximately 10 days later. Larvae then transform into pupae after an additional 10 days.

The second generation of European corn borer moths emerge from the stalks about 8 days after pupating, and lay eggs on the underside of leaves, leaf collars and on the ear husks during tasseling (VT) and silking (R1). Approximately 1 week later, the second-generation eggs begin to hatch. European corn borer larvae burrow into the stalks and ear shanks and feed on developing kernels. Fifth-instar larvae overwinter in stalks and residue left on the field. The winter survival potential of larvae is directly related to the amount of residue remaining in the field, with greater survival occurring with increased levels of residue.

Both the single (univoltine) and two (bivoltine) generation European corn borer moths may visit fields that are located in the center of the state. This phenomenon has been observed as far south as Lake, Minnehaha and Moody counties.

European Corn Borer Injury to Corn

Tunneling injury attributed to European corn borer results in stalk breakage, reduction in water and nutrient transport, secondary infection with stalk rot fungi, and ultimately yield loss. Injury to ear shanks and kernels can result in ear drop, loss of grain quality and secondary infection of mycotoxin-producing fungi (see Chapter 46 for more information on mycotoxins). Leaf feeding by early instar larvae causes "shot hole" and "windowpane" type injuries that are usually not serious enough to reduce photosynthesis. However, leaf feeding injury can be used to indicate the presence of European corn borer larvae in the field. The timing of larval infestation affects final yield (Table 51.3), with northern parts of the state being

Table 51.3 Estimated yield loss per corn borer larva at specific corn growth stages:

Growth stage	% Yield loss/larva/plant
V10 (midwhorl)	5.9
V16 (green tassel)	5.0
R1 (pollen shed)	4.0
R2 (blister)	3.1
R4 (dough)	2.4

(After North Central Regional Extension publication No. 327)

more susceptible to economic losses because larval feeding occurs throughout the entire season. The first generation of the bivoltine European corn borer tends to cause more injury than the second-generation because they occur during a more sensitive growth stage of the corn.

European Corn Borer Management: Bt-corn Hybrids, Scouting and Insecticides

Bt-corn hybrids targeting European corn borer produce toxins in their leaves, stalks and ears that negatively effect larvae (Table 51.4). These Bt-corn hybrids have performed very well during outbreaks of the European corn borer. However, the severity of corn borer infestations fluctuates from year to year. The decision to deploy Bt-corn hybrids is made before planting and before the extent of this late-season problem is known. Therefore, techniques to reduce the economic risk associated with decisions to choose treatments and varieties are needed.

Table 51.4 Bt-corn toxins that provide resistance to European corn borer larvae.

Bt toxin(s)	Trade name
Cry1Ab	Agrisure CB/LL Agrisure GT/CB/LL Agrisure CB/LL/RW Agrisure 3000GT Agrisure Artesian 3011A Agrisure Viptera 3110 Agrisure Viptera 3111 YieldGard VT Triple
Cry1F	Herculex I Herculex XTRA Optimum AcreMax 1 Optimum TRIsect
Cry1A.105 + Cry2Ab2	Genuity VT Double PRO Genuity VT Triple PRO Genuity VT Double PRO RIB Complete Genuity VT Triple PRO RIB Complete
Cry1Ab + Cry1F	Agrisure 3122 E-Z Refuge Agrisure Viptera 3220 E-Z Refuge Agrisure Duracade 5122 E-Z Refuge Agrisure Duracade 5222 E-Z Refuge Optimum AcreMax Optimum AcreMax Xtra Optimum AcreMax XTreme Optimum Intrasect Optimum Intrasect Xtra Optimum Intrasect XTreme
Cry1A.105 + Cry2Ab2 + Cry1F	Genuity SmartStax Genuity SmartStax RIB Complete Refuge Advanced Powered by SmartStax

Bt corn may be most suitable for planting in areas with high previous history of univoltine European corn borer populations (Fig. 51.9). Univoltine populations are less predictable than bivoltine European corn borer. In bivoltine areas, corn borer outbreaks often decline to levels below economic thresholds in a year after an outbreak. When corn-on-corn rotations are used, the increased risk of European corn borer may be great enough to warrant regular planting of Bt corn. Refuges of non-Bt corn must be planted in or around fields with corn hybrids containing Bt toxins targeting European corn borer. Scouting is needed to maximize the effectiveness of insecticides (Table 51.5). Insecticide treatments can be effective against this pest.

Table 51.5 Estimated timing for European corn borer scouting:

1. Look for egg masses, newly hatched larvae, and signs of injury on leaves in June and July.
2. V8-R1 (green tassel through pollen shed) for univoltine corn borer.
3. V8-V14 (mid- to late-whorl) for first-generation bivoltine corn borer.
4. R1-R2 (silking through blister) for second-generation bivoltine corn borer.

Black Cutworm (*Agrotis ipsilon*, Hufnagel)

Pest Highlights

- Black cutworm larvae feed on corn seedlings early in the season.
- Bt toxins Cry1F and Vip3A are effective against black cutworm.
- Significant stand loss can occur if the seedlings are cut below the growing point.
- Black cutworm does not overwinter in South Dakota. Moths migrate into the state in early spring and are attracted to wet and weedy fields.

Black Cutworm Description

Black cutworm larvae vary in color from dark brown to black and are approximately 1½-inches long

when mature (Fig. 51.10). Their skin has a rough, pebbly texture. Larvae have three pairs of true legs and four pairs of abdominal prolegs. Adult black cutworm are dark brown in color with a dark mottling across each forewing (Fig. 51.11).

Figure 51.10 A black cutworm larva on a corn leaf. (Courtesy of Adam J. Varenhorst)

Figure 51.11 A black cutworm moth. (Courtesy of Robert J. Bauernfeind, Kansas State University, Bugwood.org)

Black Cutworm Biology and Injury to Corn

Moths start migrating into South Dakota from the southern U.S. in early April. Strong southerly winds influence the transport, distribution and severity of black cutworm infestations. Female moths deposit eggs onto weeds and crop residues prior to corn planting. Upon hatching, black cutworm larvae feed on weeds and move to corn seedlings when they emerge in May and early June. Black cutworm larval feeding results in cutting of corn seedlings, which may occur at or below the soil surface. Feeding that occurs below the growing point can result in extensive seedling stand loss.

Black Cutworm Scouting and Management

There are Bt-corn hybrids that produce toxins that are effective against black cutworm larval feeding. Bt toxins Cry1F and Vip3A are resistant to black cutworm. Many seed treatments are also labeled for management of black cutworm, including clothianidin and thiamethoxam.

Weed management can greatly influence black cutworm populations. First, adult female black cutworm lay eggs on low-lying weeds and plant debris. Fields with no-till or reduced-tillage management can attract egg-laying females. Second, having weeds within a field can reduce the risk of injury to corn because black cutworm larvae develop better on many weed species than they develop on corn. Black cutworm larvae should starve to death if weeds and plant residue are tilled into the soil more than 2 weeks before corn planting.

Conventional insecticides can be used in conjunction with scouting to manage black cutworm. Black cutworm larvae are nocturnal and hide during the day. Therefore, scouting focuses on larval feeding injury. Scouting for black cutworm larval feeding injury should begin at the VE (germination and emergence) stage and continue through the V5 (fifth leaf) stage. Fifty plants should be examined throughout a field, with special attention given to areas of the field that have a history of increased moisture or weeds. Look for plants that show signs of cutting or leaf feeding. Measure the length of any black cutworm larvae found. An insecticide treatment is recommended if 5% (2.5 in 50) of the seedlings scouted show signs of cutting or leaf feeding and if black cutworm larvae are less than 1 inch. For a list of insecticides registered for black cutworm management on corn, please refer to the current edition of the South Dakota Pest Management Guide: Corn.

Western Bean Cutworm (*Striacosta albicosta*, Smith)

Pest Highlights

- Western bean cutworm larvae feed on developing kernels late in the season.
- Bt toxins Cry1F and Vip3A are effective against western bean cutworm.
- Western bean cutworm can reduce yields up to 40%.
- Injured ears may be susceptible to mycotoxin-producing fungi.

Western Bean Cutworm Description

Western bean cutworm larvae have a brown to gray body that is about 1¼-inch long at maturity. Larvae have an orange-brown head with a black dorsal shield located directly behind the head. The larvae have three pairs of true legs and four pairs of abdominal prolegs (Fig. 51.12). Western bean cutworm moths are approximately ¾-inch long, brown in color, with a distinct white band on the leading edge of their forewings (Fig. 51.13).

Figure 51.12 Western bean cutworm larva on a corn leaf. (Courtesy of Adam Sisson, Iowa State University, Bugwood.org)

Figure 51.13 Western bean cutworm moth on a corn leaf. (Courtesy of Adam Sisson, Iowa State University, Bugwood.org)

Western Bean Cutworm Biology and Injury to Corn

In South Dakota, western bean cutworm moths begin flying in early July and reach peak flight populations during the third or fourth week of July or when corn is between the VT (tasseling) and R1 (silking) stages. Female moths lay eggs on top of the leaves in the upper canopy. The eggs hatch within a week and the first-instar larvae begin migrating toward the developing ears. Larvae usually go through five instars. The third- through fifth-instar larvae feed on developing kernels for approximately one month before migrating to the soil, where they prepare to overwinter. Once in the soil, the larvae construct earthen cells that are 5 to 10 inches below the surface.

Several western bean cutworm larvae can feed simultaneously on a single ear of corn, which can result in yield reductions by as much as 40% per plant. Damaged ears may also be susceptible to infection from mycotoxin-producing fungi.

Western Bean Cutworm Scouting and Management

Bt-corn hybrids that express either the Cry1F or Vip3A toxins provide resistance to western bean cutworm larvae. Scouting for western bean cutworms should start at VT (green tassel) stage and continue through the R3 (milk) stage. Eggs and newly hatched larvae are usually found in the silks or leaves in the upper canopy. At least 100 plants (10 plants from 10 locations on the field) per 40-acre field should be inspected to accurately gauge the infestation level. Both the center and borders of the cornfield should be inspected. Western bean cutworms should be managed if 8% of the scouted plants have eggs or newly hatched larvae. For insecticides to be effective, they must be applied before the larvae enter the ears. For a list of insecticides that are currently registered for western bean cutworm management on corn, please refer to the current edition of the South Dakota Pest Management Guide: Corn.

Armyworm

Fall Armyworm (*Spodoptera frugiperda*, J.E. Smith), and True Armyworm (*Mythimna unipuncta*, Haworth)

Pest Highlights

- Armyworms do not overwinter in South Dakota and are considered minor pests of corn.
- Fall armyworms are attracted to late-planted corn and will feed on foliage and ears.
- Corn near the field margins or fields with grass established prior to planting are at greater risk for true armyworm infestations.
- Young corn (VE-V8) is more susceptible to true armyworms.

Figure 51.14 Fall armyworm larva on a leaf. (Courtesy of Russ Ottens, University of Georgia, Bugwood.org)

Figure 51.15 Fall armyworm moth. (Courtesy of Lyle Buss, University of Florida, Bugwood.org)

Fall Armyworm Description

Fall armyworm larvae vary greatly in color, ranging from tan to green or even black. The larvae have a characteristic white inverted "Y" on the front of their dark brown to black heads. They also have three narrow, yellow-white lines that run the length of their bodies. Each segment of their body has six black tubercles or spots. Fall armyworm larvae have three pairs of true legs and four pairs of abdominal prolegs (Fig. 51.14). Adult fall armyworm moths have forewings that are dark grey with light- and dark-grey markings. The tip of each forewing has a characteristic white spot. Their hindwings are light grey in color (Fig. 51.15).

Fall Armyworm Biology and Injury

Fall armyworm moths migrate from the Gulf states and have one generation per year in South Dakota. The female fall armyworm preferentially lays eggs in late-planted corn from July to August. Eggs generally hatch five to seven days after oviposition, and the larvae will begin feeding on corn. Initially, larvae feed in protected areas, including the whorl. As larvae mature they feed on the leaves with the exception of the tough midrib. Feeding injury from fall armyworm results in jagged edges of leaves where defoliation has occurred. During high levels of infestation, larvae may also feed on the ears where they consume developing kernels.

Fall Armyworm Scouting and Management

Late-planted cornfields and corn near the margins should be scouted for fall armyworms. Examine 20 plants in the field to determine whether fall armyworms are present. Evidence of fall armyworm feeding includes leaves that have a ragged appearance from defoliation, and the presence of frass that resembles sawdust near the whorl. The presence of fall armyworm feeding on corn ears is indicated by an entry hole in the husk and the presence of larvae. When 80% of plants are infested with fall armyworm larvae, treatment may be necessary. However, late-season infestations are difficult to manage with insecticides due to plant height and the location of the larvae within the whorl. Insecticide management of this pest is frequently not economical. For a list of insecticides registered for fall armyworm management on corn, please refer to the current edition of the South Dakota Pest Management Guide: Corn. Bt corn may also manage fall armyworm injury. Bt toxins that are efficacious against fall armyworm include Cry1F, Vip3A, and Cry1A.105 + Cry2Ab2.

True Armyworm Description

True armyworm larvae vary in color from tan to dark green to black. They have a dull orange stripe on each side of their body, and a network of black lines present on their orange head. True armyworm larvae have three pairs of true legs and four pairs of abdominal prolegs with dark bands (Fig. 51.16). True armyworm moths are tan to light brown in color with a small white spot in the center of each forewing (Fig. 51.17).

Figure 51.16 True armyworm larva feeding on a corn leaf. (Courtesy of Adam J. Varenhorst)

Figure 51.17 True armyworm moth. (Courtesy of Whitney Cranshaw, Colorado State University, Bugwood.org)

True Armyworm Biology and Injury

True armyworm is a migratory pest that overwinters in the southern U.S. It may have as many as three generations per year in South Dakota, but only the first generation pose a risk to corn. Female moths are attracted to and lay eggs in fields with living, grassy ground cover, including weeds or cover crops. When eggs hatch, the larvae begin to preferentially feed on grassy hosts. If initial hosts are consumed or destroyed, larvae will readily move to and feed on corn. Early vegetative corn (VE-V8) is at greater risk for defoliation by true armyworm larvae. Defoliation that occurs to corn after V8 is generally minimal, and does not require management. For young corn, the larvae will begin feeding on the lower leaves of the plant, and work towards the whorl (Fig. 51.18). True armyworm larvae consume all leaf tissues, excluding the midrib. There are instances during high infestations where entire corn seedlings will be removed by true armyworm larval feeding (Fig. 51.19).True armyworm larvae are nocturnal and will hide in the whorl of the plant during the day. However, true armyworm larvae do not tunnel into the stalk, and on larger plants larvae do not feed on the growing point. Feeding by true armyworm larvae results in jagged leaf edges, and in instances of severe defoliation only the leaf midrib will remain.

Figure 51.18 True armyworm larva feeding on the whorl. (Courtesy of Adam J. Varenhorst)

True Armyworm Scouting and Management

Scouting for true armyworm should occur near the field margins and be intensified for fields that had grassy weeds or cover crops present prior to planting. To reduce the potential for a true armyworm infestation, weeds and cover crops should be removed at least two weeks prior to planting. To scout for true armyworm, examine 20 random plants for signs of defoliation. Treatment is recommended for corn seedlings (VE-V2) if 10% or more of the plants are injured and the larvae that are less than ¾-inch in length are present. For corn that is in the 7-8 leaf stage (V7-V8) treatment is recommended if 25% or more of the leaf area is removed, there are more than eight larvae present per plant, and the larvae are less than ¾-inch in length. Larvae that are smaller than ¾-inch in length have the potential to feed for another

Figure 51.19 Defoliation caused by true armyworm. (Photo courtesy of Adam J. Varenhorst)

week and may cause subsequent defoliation. If treatment is necessary, please refer to the current edition of South Dakota Pest Management Guide: Corn for a list of insecticides that are currently registered for true armyworm management on corn. At present, there are no Bt toxins or seed treatments labeled for true armyworm management.

Common Stalk Borer (*Papaipema nebris*, Guenee)

Pest Highlights

- Common stalk borer is an occasional pest in South Dakota.
- Corn near field margins or fields with dense grassy weed history have the greatest risk of infestation.
- Infested corn will have irregular holes in the whorl, and may be bent or stunted due to abnormal growth.
- Young corn (V1-V7) is more susceptible to common stalk borer injury.

Figure 51.20 Common stalk borer larva on a corn leaf. (Courtesy of Adam J. Varenhorst)

Figure 51.21 Common stalk borer moth. (Courtesy of Mark Dreiling, Bugwood.org)

Figure 51.22 Defoliation caused by common stalk borer larvae. (Courtesy of Adam J. Varenhorst)

Common Stalk Borer Description

Common stalk borer larvae are approximately 1¼-inch long and have three pairs of true legs and four pairs of abdominal prolegs. Younger larvae have a characteristic purple saddle and cream-colored stripes on their abdomens (Fig. 51.20). The colors of the larvae fade as they mature. Larvae have an orange head with a black stripe on each side. Common stalk borer moths are red-brown in color (Fig. 51.21).

In South Dakota, common stalk borer has one generation per year. During the fall, female moths preferentially lay eggs on thin-stemmed, perennial grasses over annual, wide-leaved grasses or broadleaf plants. Eggs overwinter and hatch between mid-April and early June the following year. Maturing larvae initially feed in the stems of grasses and weeds until they outgrow their initial plant host. Larvae will search for larger hosts, including corn. Common stalk borer larvae primarily cause injury to corn by tunneling into the stalk but also feed on corn leaves. When larvae feed on the whorls, new leaves appear ragged when they unfurl. Larvae may also kill the plant by feeding on the growing point (Fig. 51.22), resulting in stand loss and ultimately yield loss.

Common Stalk Borer Scouting and Management

Infestations are more likely to occur near field margins where grasses or weeds are present. Large-stemmed weeds, such as giant ragweed, are preferred, although the host range is as large as 176 plant species. Minimum or no-till cornfields where grass or weeds are present prior to planting are also at an increased risk for infestation. Corn is most susceptible to common stalk borer when it is between the V1-V5 growth stages, and field margins are at greater risk of injury. Corn adjacent to grassy areas should be scouted by checking 30 plants from May to June. Common stalk borer infestations can be detected by observing ragged holes in the newly emerged leaves and the presence

of frass that resembles sawdust near the center of the plant (Fig. 51.22). Table 51.6 contains threshold information for common stalk borer. If an early infestation is detected, insecticides may be used to manage the common stalk borer. However, applying insecticides to infested corn is generally not effective because larvae are protected within the plant. Insecticide applications should target common stalk borer larvae as they migrate from weedy hosts to corn, which typically occurs from late May to approximately June 20 in South Dakota. A list of insecticides registered for management of common stalk borer on corn can be found in the current edition of the South Dakota Pest Management Guide: Corn. For fields with infestations occurring near field margins, the first 4-6 rows of corn should be treated with insecticide during larvae movement. Removing weedy hosts from the field margins prior to corn planting may also reduce the populations of the common stalk borer. However, this may increase infestation levels if corn seedlings are present when weeds and grasses are destroyed. At present, only the Vip3A Bt toxin is labeled for management of common stalk borer.

Table 51.6 Economic threshold for common stalk borer larvae in corn expressed as the percentage of corn whorls infested[1].

Plant Stage	$3/Bushel				$4/Bushel				$5/Bushel			
	150[a]	175	200	225	150	175	200	225	150	175	200	225
V1	5.8	4.9	4.3	3.8	4.3	3.7	3.2	2.9	3.5	3.0	2.6	2.3
V2	7.1	6.0	5.3	4.7	5.3	4.5	4.0	3.5	4.2	3.6	3.2	2.8
V3	9.3	8.0	7.0	6.2	7.0	6.0	5.3	4.7	5.6	4.8	4.2	3.7
V4	9.9	8.5	7.4	6.6	7.4	6.4	5.6	5.0	6.0	5.1	4.5	4.0
V5	11.3	9.7	8.5	7.6	8.5	7.3	6.4	5.7	6.8	5.8	5.1	4.5
V6	19.8	17.0	14.9	13.2	14.9	12.8	11.2	9.9	11.9	10.2	8.9	7.9
V7	54.7	46.9	41.1	36.5	41.1	35.2	30.8	27.4	32.8	28.2	24.6	21.9

[1]Assumes management cost of $10 per acre and 70% mortality of treated larvae.
[2]Economic threshold = Management cost / (corn price x [proportion of yield loss x expected yield] x .7)
Table adapted from Rice and Davis 2010 and Hodgson 2014.

Corn Aphids

Bird Cherry Oat Aphid (*Rhopalosiphum padi*, Linnaeus) and Corn Leaf Aphid (*Rhopalosiphum maidis*, Fitch)

Pest Highlights

- Bird cherry oat aphids infest the stalk near leaf collars and the ear.
- Corn leaf aphids mainly infest the whorl, tassel, and developing ears.
- Maize dwarf mosaic virus can be transmitted by corn leaf aphids.
- Heavy infestations may reduce photosynthesis, pollination, and ear development.
- Black sooty mold is an indicator of large aphid populations.

Figure 51.23 Wingless bird cherry oat aphids on a corn plant. (Courtesy of Adam Sisson, Iowa State University, Bugwood.org)

Bird Cherry Oat Aphid Description and Biology

The nymphs and adults of the bird cherry oat aphid are teardrop- or pear-shaped and dark green to olive in color. These aphids can be identified by a characteristic rusty red-orange patch present at the end of their abdomens near their cornicles (tailpipes) (Fig. 51.23). There are both winged and wingless forms of the bird cherry oat aphid. These aphids prefer small grains, but can also be found on corn.

Corn Leaf Aphid Description and Biology

The corn leaf aphids vary in color from green-olive to blue-green and have rectangular-shaped bodies (Fig. 51.24). There are both winged and wingless forms of the corn leaf aphid. These aphids prefer sorghum but will readily feed on corn as well.

Figure 51.24 A colony of corn leaf aphids feeding on a corn tassel. (Courtesy of Kansas Department of Agriculture, Bugwood.org)

Bird Cherry Oat and Corn Leaf Aphid Scouting and Management

The bird cherry oat aphids often feed on the stalk near leaf collars. When ears are present, the bird cherry oat aphids can be found near the shank and also under the first few layers of the husk. The corn leaf aphids often feed within the whorl but can also be found feeding on upper leaves. The corn leaf aphid will also readily feed on the tassels and ears when present.

When scouting for both species of aphids stop at five locations throughout the field and randomly choose 20 plants at each location to inspect. Examine the whorl and the underside of the leaves to determine whether either species of aphid is present. The presence of black sooty mold, which grows on the honeydew produced by the aphids can be used as an indicator of aphid infestations. The presence of ants foraging on the plant may also indicate the presence of aphids. Current management recommendations indicate that treatment may be necessary if 50% of the inspected plants have more than 500 aphids on them during periods of sufficient moisture. If the plants are drought-stressed, treatment may be necessary if 50% of the inspected plants have more than 100 aphids on them. For a list of insecticides currently labeled for management of bird cherry oat aphids or corn leaf aphids on corn, please refer to the current edition of the South Dakota Pest Management Guide: Corn.

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