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Best Management Practices for Corn Production in South Dakota: Corn Insect Pests

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CHAPTER 8
Corn Insect Pests

Historically, the major corn insect pests have been corn rootworms (northern and western), European corn borer, and black cutworm. *Bt*-corn hybrids are effective against most of these pests. However, *Bt*-corn hybrids are not effective against corn leaf aphid, corn root aphid, sap beetles, corn rootworm adults, grasshoppers, white grubs, wireworms, seed corn beetle, and seed corn maggots. These insect pests can reduce corn yields. This chapter discusses the management and biology of important corn insect pests commonly observed in South Dakota.

Corn Rootworms (*Diabrotica barberi* and *Diabrotica virgifera virgifera*)

Pest highlights

- Two major species occur in South Dakota: northern corn rootworm and western corn rootworm.
- *Bt*-corn hybrids with the *Bt*-rootworm gene are effective against corn rootworm larvae.
- Crop rotation is an effective tactic in managing corn rootworms.
- Corn rootworms are currently the most damaging insect pests of continuous corn in South Dakota.

Rootworm description

Adult northern corn rootworm beetles are approximately ¼-inch long and greenish to yellowish in color, while western corn rootworm beetles are yellow with black longitudinal markings on their wings (fig. 8.1). Larvae of both species are white with a brown head and grow to a size of ⅝ inch (fig. 8.2). Both the larvae and the adults have chewing mouthparts.

Figure 8.1. Adult beetles of northern corn rootworm (top) and western corn rootworm (bottom)

(Photo courtesy of Mike Catangui, South Dakota State University)

Figure 8.2. Larvae and pupae of corn rootworms

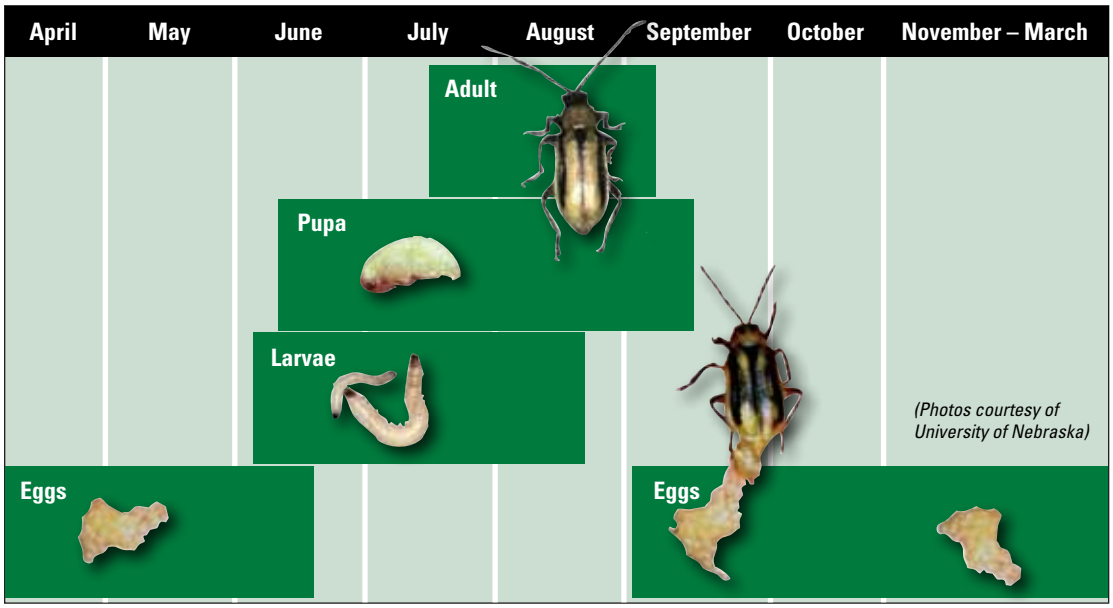
(Photo courtesy of Mike Catangui, South Dakota State University)

Rootworm biology

Rootworm larvae feed on corn roots and cannot normally survive on roots of other crops such as soybean, wheat, sunflower, and alfalfa. This feature makes crop rotation an excellent control approach. Because the most common alternative hosts for rootworm larvae are green, yellow, and giant foxtail, the control of these weed pests is important for limiting future rootworm infestations.

Rootworm eggs are laid in the soil from late summer until the female rootworm beetle adults are killed

Figure 8.3. Life cycle of the western corn rootworm in South Dakota



by the first killing frost (fig. 8.3). In South Dakota, rootworm eggs are primarily laid in cornfields, where they overwinter in the soil. Fields where corn was the previous crop will most likely have rootworm eggs waiting for the new corn crop. Eggs hatch as soon as corn roots start growing. Most injuries by rootworm larvae occur in June and July (a period of active root growth). Larvae transform into pupae in mid-July, and adult rootworm beetles emerge from the soil starting from late July through August. Adult beetles feed on corn pollen, silk, and on the leaves of corn, soybeans, sunflowers, and garden flowers.

In the larval stage, root feeding reduces water and nutrient intake (fig. 8.4) and can result in lodging (fig. 8.5). Lodged corn is difficult to harvest, decreasing harvest efficiency. Yield losses can be minimized by using *Bt*-corn hybrids, granular and liquid insecticides, and seed treatments.

Management: *Bt*-corn hybrids

Genetically engineered corn hybrids with YieldGard® Rootworm, YieldGard® Plus, YieldGard® VT Triple, Herculex® RW, Herculex® XTRA, and Agrisure® RW genes are resistant to feeding by rootworm larvae (Table 8.1). These *Bt*-corn hybrids produce proteins toxic to rootworm larvae. To prevent the development of insect resistance to *Bt*-corn, growers must seed at least 20% of a field with non-*Bt*-corn hybrids, thus creating a refuge area.

Figure 8.4. Root pruning caused by rootworm larvae on corn

(Photo courtesy of Mike Catangui, South Dakota State University)

Figure 8.5. Lodging, or "goosenecking," of corn plants as a result of rootworm injuries

(Photo courtesy of Mike Catangui, South Dakota State University)

Table 8.1. *Bt*-corn genes that confer resistance to corn against insects			
***Bt* gene trademark**	***Bt* proteins**	**Company**	**Target insects**
Agrisure® RW	Modified Cry3A	Syngenta Seeds	corn rootworm larvae
Herculex® RW	Cry34Ab1+Cry35Ab1	Dow AgroSciences and Pioneer Hi-Bred	corn rootworm larvae
YieldGard® Rootworm	Cry3Bb1	Monsanto Company	corn rootworm larvae
YieldGard® VT Rootworm	Cry3Bb1	Monsanto Company	corn rootworm larvae
Agrisure® CB	Cry1Ab	Syngenta Seeds	corn borer larvae
Herculex® I	Cry1F	Dow AgroSciences and Pioneer Hi-Bred	corn borer, black cutworm, and western bean cutworm larvae
YieldGard® Corn Borer	Cry1Ab	Monsanto Company	corn borer larvae
Agrisure® CB/RW	Cry1Ab+Modified Cry 3A	Syngenta Seeds	corn borer and corn rootworm larvae
Herculex® XTRA	Cry1F+Cry34Ab1+Cry35Ab1	Dow AgroSciences and Pioneer Hi-Bred	corn borer, black cutworm, western bean cutworm, and corn rootworm larvae
YieldGard® Plus	Cry1Ab+Cry3Bb1	Monsanto Company	corn borer and corn rootworm larvae
YieldGard® VT Triple	Cry1Ab+Cry3Bb1	Monsanto Company	corn borer and corn rootworm larvae
More information about *Bt* genes is available at the following: Agrisure - http://www.agrisuretraits.com Herculex® - http://www.dowagro.com/herculex/ YieldGard® - http://www.yieldgardvt.com			

Rootworm seed treatments

Insecticidal seed treatments available to corn growers are clothianidin (Poncho®), imidacloprid (Gaucho®, Prescribe®), or thiamethoxam (Cruiser®). These systemic insecticide seed treatments are applied to seed before bagging and sale.

Rootworm insecticides

Granular or liquid rootworm insecticides are applied in-furrow or very close to the seed furrow during planting. Many different insecticides can be used for rootworm larval control. Information about these control agents is available at the SDSU Extension Entomology Web site (http://plantsci.sdstate.edu/ent).

Scouting and economic threshold

Corn ears during the R1 to R2 (silking to blister) stages may be scouted for adult beetles to predict the potential for rootworm infestation the following season. In continuous corn, an average of 3 beetles per 10 ears examined is considered the economic threshold for control treatment. More rootworm scouting information can be found at http://entomology.unl.edu/pmguides/crwlarv.htm.

European Corn Borer (*Ostrinia nubilalis*)

Pest highlights

- South Dakota has both the univoltine (1 generation) and bivoltine (2 generation) ecotypes.
- *Bt*-corn hybrids with the *Bt*-corn borer gene are effective against this pest.
- Univoltine corn borers can be more damaging and harder to manage than bivoltine corn borers.
- Yield loss can range from 2 to 6% per larva per plant.

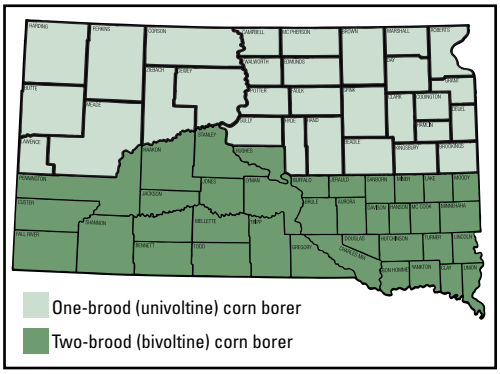
Figure 8.6. European corn borer larva

(Photo courtesy of Jon Kieckhefer, South Dakota State University)

Figure 8.7. European corn borer moths

(Photo courtesy of Mike Catangui, South Dakota State University)

Figure 8.8. Predicted distribution of univoltine and bivoltine corn borers in South Dakota



Corn borer description

A fully grown corn borer larva is about 1-inch long. It has a dark brown head and its body is light tan with brown spots (fig. 8.6). The adult moth is triangular in shape, yellowish in color with wavy markings on wings, and 1/2-inch long (fig. 8.7). Male moths are darker in color than female moths.

Corn borer biology

Corn borers have 4 stages of development: egg, larva, pupa, and adult. These stages cummulatively represent 1 generation. Larvae have 5 instars (larval stages) that increase in size as the larva develops. At the fifth instar stage, a larva prepares to pupate and become an adult. Corn borers are characterized by their number of generations within a season. In the northern environment, there is generally only 1 generation (univoltine); but in central areas of the Corn Belt, 2 generations can be produced each season (bivoltine). In southern areas of the United States, 3 generations are possible (multivoltine).

Univoltine corn borers (1 generation per year)

The univoltine corn borer occurs in the northern counties of South Dakota (fig. 8.8). Univoltine corn borer moths start flying in mid-June. Peak populations occur in mid-July. Moths lay eggs mainly on the underside of leaves of pre-tasseling (V18) to tasseling (VT) corn. Eggs hatch within a week, and the newly hatched larvae first feed on the leaf collars and then migrate to the tassels to feed on pollen.

The univoltine larvae stay on the corn plants from June through harvest and overwinter in stalk residues left on the field. They transform into pupae and moths in the following spring.

Bivoltine corn borer (2 generations per year)

In the southern portion of the state, corn borers can have 2 generations (fig. 8.8). These moths start flying in mid-May and the adult moths lay eggs on the underside of the leaves when corn is between the V6 to V9 growth stages. Newly hatched larvae first feed in the whorl, causing a "shot-holing" type injury that is visible when leaves unfurl (fig. 8.9). Second- and third-instar larvae feed on the leaf surface and midribs, causing a "window paning" type injury. Fourth-instar larvae tunnel into the stalk, molt into a fifth-instar larvae after 10 days, then transform into pupae after about the same amount of time. Tunnels in the stalk produced by the larvae are very injurious because they interfere with water and nutrient transport.

Adult moths emerge from the stalk after 8 days. These second-generation moths lay eggs on the underside of leaves, leaf collars, and ear husks at tasseling (VT) and silking (R1) corn. Eggs hatch into second-generation corn borer larvae that burrow into the stalks and ear shanks and feed on developing seeds. Fully grown (fifth-instar) larvae overwinter on stalks and stover left on the field. The winter survival potential of larvae increases with the amount of residue remaining in the field.

In transition zones, flight paths of univoltine and bivoltine corn borers converge, and both can exist in the same field. This phenomenon has been observed along the northern border of Minnehaha County and along the southern borders of Lake and Moody counties. More information about both corn borer moth flight-monitoring data and corn borer biology can be found at the SDSU Extension Entomology Web site (http://plantsci.sdstate.edu/ent/).

Figure 8.9. Shot-hole symptoms of corn borer infestations

(Photo courtesy of Mike Catangui, South Dakota State University)

Table 8.2. Estimated yield loss per corn borer larva at specific corn growth stages

Growth stage	% Yield loss/larva/plant
V10 (mid-whorl)	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)

Corn borer injuries to corn

Corn borer injury can result in stalk breakage, reduction in water and nutrient transport, secondary infection with stalk rot fungi, and yield loss. Injuries to ears can result in ear drop, reduced grain quality, and secondary infection with mycotoxin-producing fungi. Leaf feeding by early instar larvae causes shot-hole and window-paning type injuries that are usually not serious enough to reduce photosynthesis. However, these leaf injury symptoms serve as indicators of the presence of corn borers. The timing of larval infestation affects final yield (Table 8.2). In general, the univoltine corn borer is more injurious to corn than the bivoltine corn borer because larvae of the former stay in the plants the entire season. In bivoltine corn borer, the first-generation larvae are generally more injurious than the second generation because they occur during the plant stage that is more sensitive to stress.

Corn borer management

Bt-corn hybrids with YieldGard® Corn Borer, YieldGard® Plus, YieldGard® VT Triple, Herculex® I, Herculex® XTRA, Agrisure® CB, and Agrisure® CB/RW genes produce *Bt* proteins in their leaves, stalks, and ears that are toxic to the corn borer larvae. *Bt*-corn hybrids have performed very well during corn borer outbreaks. However, the severity of corn borer infestations fluctuates from year to year.

The decision to deploy *Bt*-corn hybrids is made before planting. Therefore, techniques are needed to reduce the economic risk associated with treatment and variety choice decisions.

Bt-corn may be most suitable for planting in areas where the univoltine corn borer occurs (fig. 8.8). This pest is less predictable than the bivoltine corn borer. In bivoltine regions, corn borer outbreaks often decline to levels below economic thresholds in the year after an outbreak. However, the risk of corn borers may be sufficient to warrant regular planting of *Bt*-corn hybrids if corn follows corn in the rotation. For more information on risk, check the annual corn borer moth flights at the SDSU Extension Entomology Web site (http://plantsci.sdstate.edu/ent/). To prevent the development of insect resistance to *Bt*-corn, growers must plant at least 20% of their corn acres with non-*Bt*-corn hybrids. Information on refuge requirements and insect resistance management can be found at http://www.pioneer.com/CMRoot/Pioneer/biotech/irm/irmbroch.pdf and at http://www.monsanto.com/monsanto/ag_products/pdf/stewardship/2008_YieldGard®_irmguide.pdf.

Corn borer scouting and insecticides.

Insecticide treatments can be effective against corn borers. South Dakota State University research indicates that insecticide is an effective control if applied at the right time and rate. Corn properly treated with insectides often produces yields similar to *Bt* hybrids. Scouting is critical to maximize the effectiveness of insecticides (Table 8.3).

Table 8.3. Corn borer scouting, timing, and additional information

Look for egg masses, newly hatched larvae, and signs of injury on leaves:

- V8-V14 (mid- to late-whorl) for 1st-generation bivoltine corn borer
- V16-R1 (green tassel through pollen shed) for univoltine corn borer
- R1-R2 (silking through blister) for 2nd-generation bivoltine corn borer

Details for calculating economic thresholds and a list of labeled insecticides for corn borers can be found at the SDSU Extension Entomology Web site (http://plantsci.sdstate.edu/ent/).

Western Bean Cutworm (*Striacosta albicosta*)

Pest highlights

- Western bean cutworm larvae feed on the developing seeds in the corn ears late in the season.
- *Bt*-corn hybrids that have Herculex® I and Herculex® XTRA genes are resistant to this pest.
- *Bt*-corn hybrids with the YieldGard® Corn Borer, YieldGard® Plus, YieldGard® VT Triple, Agrisure® CB, and Agrisure® CB/RW genes are not effective against this pest.
- This pest can reduce yields up to 40%.
- Injured ears may be susceptible to mycotoxin-producing fungi.

Cutworm description

The western bean cutworm larva is about 1¼-inch long when fully grown and has an orange-brown head, black dorsal shield behind the head, and a brownish body with gray markings (figs. 8.10 and 8.11). The adult moth is about ¾-inch long, brown in color, and has a distinct white band on the leading edge of its forewings (fig. 8.12).

Cutworm biology

In South Dakota, western bean cutworm moths start flying in early July and reach peak numbers during the third or fourth week of July, when corn is between the VT (tasseling) and R1 (silking) stages. The moths lay eggs on the upper surface of the leaves in the upper canopy. The eggs hatch within a week and the first-instar larvae begin migrating toward the developing ears near egg sites. Larvae usually go through 5 instars, or stages. The third- through fifth-instar larvae feed on developing kernels for approximately 1 month (fig. 8.11), then migrate to the soil where they prepare for overwintering. Once in the soil, the larvae construct earthen cells 5 to 10 inches belowground in which to overwinter.

Western bean cutworm injuries to corn

Several cutworm larvae can feed simultaneously on a single ear. Early studies in Colorado indicate that direct feeding on the developing ears can result in up to 40% loss in grain yield. Injured ears may also be susceptible to infection with mycotoxin-producing fungi (fig. 8.11).

Figure 8.10. Western bean cutworm larva

(Photo courtesy of Mike Catangui, South Dakota State University)

Figure 8.11. Western bean cutworm injury

(Photo courtesy of Mike Catangui, South Dakota State University)

Figure 8.12. Western bean cutworm moth

(Photo courtesy of Mike Catangui, South Dakota State University)

Western bean cutworm management

Bt-corn hybrids with Herculex® I and Herculex® X-TRA genes produce the Cry1F protein that provides resistance to western bean cutworm larvae. However, *Bt*-corn hybrids with YieldGard® Corn Borer, YieldGard® Plus, YieldGard® VT Triple, Agrisure® CB, and Agrisure® CB/RW genes do not provide resistance to western bean cutworm larvae.

Western cutworm scouting and insecticides

Scouting for western bean cutworms should start at the V16 (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. Because the timing of spray application is very important (the insecticide must be applied before the larvae enter the ears), scouting must also be timed accordingly. At least 100 plants (10 plants from 10 locations on the field) per 40-acre field must be inspected to accurately gauge the infestation level. Both the center and borders of the cornfield must be inspected. This pest should be controlled if 8% of the plants have eggs or newly hatched larvae. For insecticides to be effective, the insecticide must be applied before the larvae enter the ears. Information on different insecticides is available at the SDSU Extension Entomology Web site (http://plantsci.sdstate.edu/ent/).

Black Cutworm (*Agrotis ipsilon*)

Pest highlights

- Black cutworm larvae feed on corn seedlings early in the season.
- Only Herculex® I and Herculex® XTRA *Bt*-corn hybrids are effective against this pest.
- If the seedlings are cut below the growing point, significant stand loss can result.
- Black cutworms do not overwinter in South Dakota. Moths migrate into the state in early spring and are attracted to wet and weedy fields.

Figure 8.13. Black cutworm larvae, pupa, and cut seedling

(Photo courtesy of Mike Catangui, South Dakota State University)

Figure 8.14. Missing corn seedlings due to black cutworm injury

(Photo courtesy of Mike Catangui, South Dakota State University)

Black cutworm description

A full-grown larva is about 1½-inches long, dark brown to black, and "greasy" in appearance (fig. 8.13). Under the microscope or hand lens, the skin of the larva has a rough, pebbly texture. The pupa is brown and about ¾-inch long (fig. 8.13).

Black cutworm biology

Moths start migrating into South Dakota from southern states in early April. Southerly winds influence the transport, distribution, and severity of black cutworm infestations. Eggs are deposited on weeds and crop residues before corn is planted. Black cutworm larvae initially feed on weeds, then move to corn seedlings in May through early June. Corn seedlings can be cut underground, below the growing point, resulting in extensive seedling stand loss (fig. 8.14).

Black cutworm management

Only *Bt*-corn hybrids with Herculex® I and Herculex® X-TRA are considered resistant to black cutworm larvae. Seed treatments of clothianidin or thiamethoxam provide protection from cutworm damage.

Black cutworm scouting and insecticides

Scouting for black cutworm larvae should start at the VE (germination and emergence) stage and continue on through V4 (fourth leaf). Insecticide treatment is recommended if 5% (1 in 20) of the seedlings show signs of cutting or leaf feeding and if the larvae are less than 1-inch long. Information on different insecticides is available at the SDSU Extension Entomology Web site (http://plantsci.sdstate.edu/ent/).

Sap Beetles (*Glischrochilus quadrisignatus, Carpophilus lugubris, Carpophilus dimidiatus*)

Pest highlights

- Both the larval and adult stages feed on corn ears.
- Infested ears may become susceptible to infection with mycotoxin-producing fungi.
- Three species of sap beetles commonly infest corn in South Dakota.
- Adults can overwinter in soil, crop residues, and unharvested ears.

Sap beetles description

The picnic beetle (*G. quadrisignatus*) is 1/3-inch long and shiny black with 4 yellowish markings on its wings (fig. 8.15). The dusky sap beetle (*C. lugubris*) is dull brown and 1/16-inch long (fig. 8.16). The corn sap beetle (*C. dimidiatus*) is 1/8-inch long and reddish brown. Larvae are whitish or pinkish and measure ¼-inch long (fig. 8.17).

Sap beetles biology

Sap beetles can overwinter in South Dakota under crop residues and in unharvested corn ears. Adults become active in the spring and presumably start feeding on crop residues and the sap of trees, laying eggs near food sources. There are 3 larval instars, and sap beetles develop from egg to adult in about a month. Several overlapping generations per growing season are possible.

Sap beetle adults appear to be attracted to corn pollen during tasseling and silking in August and follow corn leaf aphid infestations. Eggs may be laid directly on the developing corn ears, with larvae and adults feeding on developing kernels (figs. 8.15 and 8.17). Direct feeding by sap beetles does not appear to reduce yield, but injured ears may become susceptible to mycotoxin-producing fungi later in the season (fig. 8.18).

Sap beetle management

Most insecticides labeled for major corn insect pests are also labeled for use against sap beetles. Economic thresholds have not been determined. *Bt*-corn hybrids currently available are completely ineffective against sap beetles.

Figure 8.15. A picnic (sap) beetle on a corn ear

(Photo courtesy of Jon Kieckhefer, South Dakota State University)

Figure 8.16. Dusky sap beetles

(Photo courtesy of Mike Catangui, South Dakota State University)

Figure 8.17. Sap beetle larvae on a corn ear

(Photo courtesy of Mike Catangui, South Dakota State University)

Figure 8.18. Fungal infection on a corn ear after sap beetle injury

(Photo courtesy of Mike Catangui, South Dakota State University)

Corn Root Aphid (*Aphis maidiradicis*)

Pest highlights

- Corn root aphids overwinter as eggs in the nests of cornfield ants.
- Ants "farm" the aphids for their honeydew.
- The aphids feed on the sap of corn seedlings, using syringe-like mouthparts.
- Infested seedlings appear yellowish and stunted.

Corn root aphid description

Corn root aphids are plump, yellow-green to blue-green insects, about 1/16-inch long when fully grown (fig. 8.19). They have syringe-like mouthparts to withdraw sap from the roots. Corn root aphids are usually found underground, clustered around the roots of corn plants. Individual aphids can either be winged or wingless, with the former usually darker in color than the latter. Stunted and yellowish corn seedlings, along with the presence of numerous cornfield ants and ant nests, may be signs of corn root aphid infestations (fig. 8.20).

Figure 8.19. Corn root aphid adults and nymphs

(Photo courtesy of Heinrichs et al.)

Corn root aphid biology

Corn root aphids spend much of their time underground, feeding on the sap of corn roots. The honeydew that aphids excrete is used by cornfield ants as food. There is a symbiotic relationship between the ants and aphids. Aphids supply food to the ants, while the ants protect and transport the aphids. Although the corn root aphid is capable of forming wings, its dispersion is aided by cornfield ants. Corn root aphids overwinter as eggs that are cared for by cornfield ants in their nests. These eggs hatch in the spring and are carried by ants to the roots of acceptable available plants such as smartweed, wheat, and corn. Aphids can also be carried by the ants from weeds to corn later in the season. Like most aphid species, corn root aphids multiply very fast and complete their life cycles from nymphs to adults within a week. Winged aphids may be produced when a colony becomes overcrowded. High numbers of aphids withdrawing sap from the roots of corn seedlings may result in the stunting and yellowing of corn leaves (fig. 8.20).

Figure 8.20. Suspected area (due to numerous ant nests present and corn injury symptoms) of corn root aphid infestation

(Photo courtesy of Roger Barrick, South Dakota State University)

Corn root aphid management

There are currently no economic thresholds or insecticides available for use against corn root aphids on corn in South Dakota.

Corn Leaf Aphid (*Rhopalosiphum maidis*)

Pest highlights

- Corn leaf aphids mainly infest the whorl, tassel, and developing ears.
- Heavy infestations may reduce photosynthesis, pollination, and ear development.
- Maize dwarf mosaic virus can be transmitted by corn leaf aphids.
- Honeydew produced by the aphids may attract other pests, such as molds and sap beetles.

Figure 8.21. Corn leaf aphid adults and nymphs

(Photo courtesy of Jon Kieckhefer, South Dakota State University)

Corn leaf aphid description

Bluish-green wingless and winged corn leaf aphids range in size from 1/16 to 1/8 inch (fig. 8.21); both wingless and winged forms may be present. Corn leaf aphids can usually be found in the whorl, tassel, developing ears, and upper leaves. Heavily infested plants may appear "messy" or "sticky" (fig. 8.22).

Corn leaf aphid biology

Figure 8.22. Corn leaf aphids on tassel and leaf

(Photo courtesy of Mike Catangui, South Dakota State University)

Corn leaf aphids do not overwinter in South Dakota, because they are killed by frost. Winged adults arrive in June from warmer climates. Once on the corn plants, the aphids multiply very quickly by giving birth to live aphids. Initially the corn whorls are infested, but as the season progresses the infestation spreads to the emerging tassels, silking ears, and upper leaves. The entire plant potentially can be covered with corn leaf aphids. Like any other aphid species, corn leaf aphids have syringe-like mouthparts that they use for withdrawing sap. Partially digested sap is continuously excreted as honeydew. Winged aphids can migrate into nearby cornfields. Corn leaf aphids can reduce yields by directly interfering with pollination and by causing plant stress during the reproductive stages from VT to silking.

Corn leaf aphid management

Management decision-making tools are available for the corn leaf aphid. Information for scouting and estimating economic thresholds is available at http://plantsci.sdstate.edu/ent/.

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