SDSU Extension

iGrow Corn

BEST MANAGEMENT PRACTICES

Chapter: 47

Corn Diseases in South Dakota and Their Management

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The outbreak and severity of corn diseases are dependent on environmental conditions (weather, temperature, wind, rain, etc.), choice of cultural practices (no-till/minimum till, corn on corn, etc.), and the hybrid grown. Thankfully, due to corn genetic resistance and low disease pressure, South Dakota producers generally have minimal yield loss due to diseases. However, problems can exist when there are sources for the pathogen, and the climatic conditions favor rapid disease development (warm [> 75°F] and high relative humidity). In many fields, the source of the pathogen is from surface residue of susceptible plants or the soil. In some years and under specific practices such as no-till combined with corn-on-corn rotation, diseases can cause significant yield losses. To select corn hybrids that will optimize yield and minimize disease problems, it is important to understand the pathogen biology and the field history. The purpose of this chapter is to discuss how to identify corn diseases and to provide management strategies. We will discuss fungal, bacterial, nematode, and viral pathogens, which cause seed and seedling diseases, leaf diseases, stalk rots, ear rots, mycotoxins, and reduce plant vigor. Chemical control options for fungal diseases are available online at iGrow.org. The pest-management guides are updated annually. Fungicides are not effective against bacteria and viruses.

Fungal Foliar Diseases

There are several fungal pathogens that can infect corn and may cause significant yield losses in South Dakota if the right conditions occur. Yield reductions are related to hybrid susceptibility, cultural practices, inoculum presence, weather conditions, and timing of infection. Because most fungal pathogens are residue-borne – unlike rusts that must be blown up on southerly winds – fungal disease management includes residue management through crop rotation and tillage (where applicable), hybrid selection, and fungicide application.

Anthracnose Leaf Blight

Anthracnose infection tends to be high in continuous cornfields and plants that are potassium deficient. This disease is most prevalent on young corn plants when leaves are closer to the soil surface. Anthracnose of corn is caused by the fungus *Colletotrichum graminicola* and overwinters on infected corn residues (leaves and stalks). Splashing rain and wind carry the conidia spores to young corn plants where primary infection takes place. Disease development is favored by warm, moist weather (70-85°F) and high humidity.

The symptoms are oval-shaped lesions that are approximately ~1/2-inch long with a dark brown border, which is surrounded by a yellow halo (Fig. 47.1a). Under magnification (20X hand lens), small, black spines (setae, which resemble porcupine-like structures) may be observed on the dead tissue/lesion (Fig. 47.1b).

1. Select resistant varieties. Scout and keep records of diseases occurring in your field and select hybrids with good tolerance or resistance to the diseases in your area.
2. Consider residue management. If high levels of infection were present in the current year, consider doing a tillage operation to bury residue. Burying residues will help reduce the amount of inoculum in the field. The anthracnose pathogen survives on infested cornstalk residue.
3. Practice crop rotation. Rotating away from corn allows the residue to break down and therefore helps to reduce the inoculum level in the field. For fields with a history of severe corn diseases, longer rotations (> 2 years) out of corn can reduce the risk of disease development.

Figure 47.1a Anthracnose leaf blight. (Courtesy of C. Bradley)

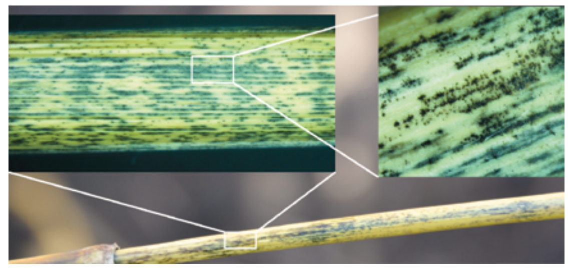

Figure 47.1b Anthracnose top dieback caused by Colletotrichum graminicola. Notice the black spots on the rind, which are a sign of the pathogen.

Common Rust

Common rust of corn is caused by the fungus *Puccinia sorghi*. Urediniospores of the fungi are blown north from Mexico and the Gulf states on the wind currents where they are deposited into South Dakota cornfields. Common rust prefers cool temperatures (60-76°F) and approximately six hours of moisture (dew, humidity) for optimal infection. Common rust occurs very frequently in South Dakota. The symptoms of common rust are small raised spots (pustules) that are a dark, reddish-brown color and are oval to elongate in shape. These pustules are scattered over both the upper and lower surface of the corn leaves (Fig. 47.2).

Because this pathogen does not overwinter in South Dakota, rotations and tillage are not effective control methods. The management for common rust includes:

1. The use of resistant hybrids. Resistance ratings may not be available for all hybrids as common rust is rarely economically damaging (Fig. 47.2).
2. Scout for early detection. Fungicides can be used to control common rust if the disease is rapidly increasing. Fungicides can be economical especially on seed corn production fields.

Figure 47.2 (a) Common rust on resistant hybrids forms a few scattered pustules. (b) Common rust can reach yield-reducing levels on susceptible hybrids. (Courtesy of Emmanuel Byamukama)

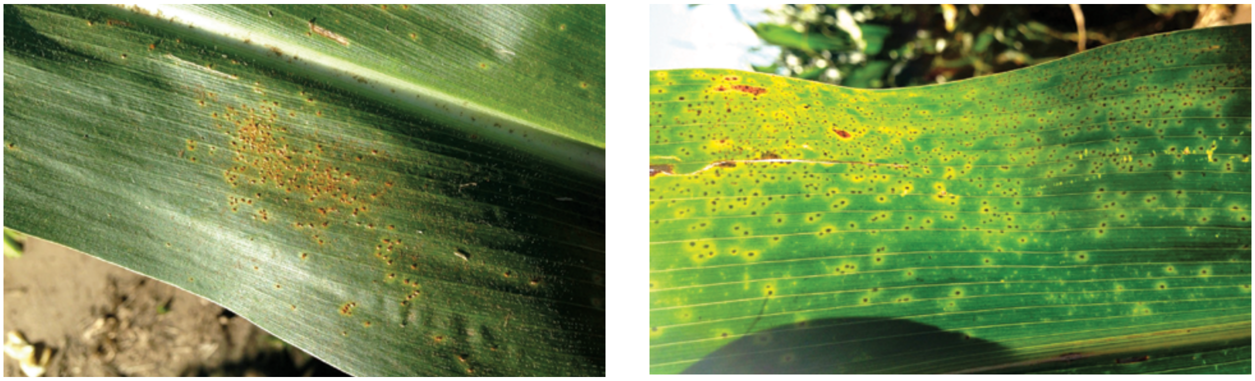

Figure 47.3 (a) Southern rust on corn. The pustules are clustered. (b) Southern rust held against light showing yellow halo around the pustules. (Courtesy of Emmanuel Byamukama)

Southern Rust

Usually southern rust reaches South Dakota when corn is around dent growth stage and rarely does it develop to reach yield-reducing levels. Southern rust is caused by the fungus *Puccinia polysora*. Urediniospores of the fungus are blown north from Mexico and the Gulf states on the wind currents where they are deposited into South Dakota cornfields. Southern rust prefers warmer temperatures (77-82°F) and approximately six hours of moisture (dew, humidity, free fall moisture, irrigation) for optimal infection.

The symptoms include small raised spots that appear primarily on the upper leaf surface, orange to light brown in color, round, and are usually densely packed on a leaf surface (Fig. 47.3a). Southern rust can be differentiated from common rust by color (light brown vs. dark red), distribution on the leaf surface (packed vs. random), halo around pustules (present vs. absent) (Fig. 47.3b), and the rapturing of the leaf surface by pustules (limited vs. extensive).

Common Smut

Corn smut is commonly observed in corn (dent, sweet, and popcorn) in South Dakota. However, corn smut is not usually an economically damaging disease. Corn plants generally are infected early in the growing season. Yield losses have been reported to be as high as 20% some years. Common smut of corn is caused by the fungus *Ustilago maydis*. Immature corn smut galls (called huitlacoche) are treated as a delicacy in Mexico. Spores from the common smut galls overwinter in the soil. These overwintering spores are called teliospores. Teliospores can be blown long distances with soil particles or carried into a new area on unshelled seed corn, and in manure from animals that are fed infected cornstalks. Spores germinate with moisture and air temperatures between 50-95°F. Common smut is most severe when young, actively growing plant tissues are wounded (Fig. 47.4).

Figure 47.4 (a) Common smut on corn ear. (b) Common smut can also develop on leaves. (Courtesy of Emmanuel Byamukama)

The symptoms for common smut include the development of a smut gall. A smut gall is composed of a mass of black, greasy, or powdery spores enclosed by a smooth, greenish-white to silvery-white membrane (Fig. 47.4a). As the spores mature, the outer covering of the gall becomes dry and papery and disintegrates, releasing the spores. Any portion of the corn plant located above ground can become infected, including, tassels, ears, leaves (Fig. 47.4b), and areas near the stem nodes and aerial roots.

Management of common smut includes:
1. Maintain appropriate soil fertility levels.
2. Avoid injury to roots, stalks, and leaves during cultivation.
3. Use smut-resistant hybrids. Dent corn tends to be more resistant to corn smut than popcorn or sweet corn.
4. Seed treatment for grain harvested from cornfields with moderate incidence of common smut.
5. Use rotations and tillage to reduce spore populations.

Crazy Top

Young corn plants subjected to saturated soil conditions are prone to crazy top infection. This is a rare disease on corn in South Dakota but is observed occasionally on a few scattered corn plants along a field edge. Crazy top is caused by the soil-borne fungus *Sclerophthora macrospora*. This fungus attacks all types of corn and a number of wild grasses. Infected grasses at the edge of the field also serve as an additional inoculum source. Crazy top develops when soils have been flooded shortly after planting or before plants are in the four- to five-leaf stage. The crazy top pathogen survives in the soil as oospores. These germinate into sporangiospores. It is the sporangiospores that produce zoospores that swim in a film of water and infect young developing corn plants.

Figure 47.5 Crazy top of corn. (a) Proliferation of what would have been the tassel and (b) chlorotic stripes on the leaf caused by crazy top pathogen. (Courtesy of Emmanuel Byamukama)

The most common characteristic of this disease is proliferation of the tassel, where instead of a normal tassel a mass of leafy structures develops (Fig. 47.5a). Sometimes infected plants may have excessive tillering and multiple small ears. Leaves of severely infected plants may show chlorotic striping (Fig. 47.5b).

The management for crazy top includes:
1. Providing adequate soil drainage. This will reduce the risk of flooding and subsequent infection.
2. Do not plant corn in low, wet spots – especially if the disease has occurred in the area before.
3. Control grassy weeds (witchgrass, foxtails, crabgrass and barnyardgrass can be infected). This fungus attacks corn and grassy weeds; controlling the weeds will reduce the inoculum buildup.
4. Seed treatment will not control crazy top of corn.

Eye Spot

Eye spot is a residue-borne disease and can be a problem in continuous cornfields and in reduced-tillage systems. Eye spot is caused by the fungus *Aureobasidium zeae* (previously known as *Kabatiella zeae*). The spores produced by this fungus are widely distributed by wind. Infection takes place during cool, wet weather. The fungus overwinters on corn residue. In the spring, the fungus produces spores that are carried to the new corn crop. The fungus may also be seed-borne, but this source of fungal inoculum is negligible when compared to the number of spores produced on infested crop residues.

Figure 47.6 Eye spot on corn. Notice the yellow halo around the lesion. (Courtesy of Emmanuel Byamukama)

Eye spot symptoms include small circular spots (lesions) about 1/8-inch in diameter (Fig 47.6). The central area of the spot dies, leaving a tan to cream-colored center surrounded by a distinct brown to purple border. The border is frequently encircled by a yellow halo that is easily seen when the leaf is held to the light.

Eye spot can be most severe in reduced-tillage systems where the crop residues are left on the soil surface. Management for eye spot includes:

1. Plant corn hybrids that have resistance to eye spot. Resistant hybrids are the main line of defense against this disease.
2. Practice crop rotation. Rotating away from corn helps to reduce the inoculum level in the field.
3. Consider residue management. Burying residues will help reduce the amount of inoculum in the field.
4. Fungicide can be used to control eye spot. Fungicides can be economical especially on seed corn production fields.

Gray Leaf Spot

Hybrid susceptibility and weather strongly influence gray leaf spot development. Gray leaf spot can develop to reach economically damaging levels especially in no-till corn-after-corn fields. Gray leaf spot is caused by the fungus *Cercospora zeae-maydis*. The fungus overwinters on infected corn residue at the soil surface. Infection takes place during prolonged warm (75-90°F) and humid conditions (> 90% relative humidity) with leaves remaining wet (from dew, irrigation, or rainfall) for twelve hours or more.

Figure 47.7 Gray leaf spot on corn. (Courtesy of Emmanuel Byamukama)

Gray leaf spot early infection symptoms are small, pinpoint lesions. Early symptoms can be easily confused with those of other diseases such as eye spot, anthracnose, and mature common rust lesions with no pustules. As lesions mature, they elongate and turn brown to gray in color. These lesions are often bound by the veins on the leaf (Fig. 47.7). Under favorable conditions, lesions can coalesce to form large, irregular areas of dead tissue on the leaves.

Gray leaf spot can reduce corn yields. Hot, dry weather will slow disease spread. Management of gray leaf spot includes:

1. Planting resistant cultivars.
2. Practice residue management. Burying the residues will help reduce the amount of inoculum from building up in the field.
3. Use crop rotations.
4. Scout the field from VT to R1 and use fungicides if the infestation is greater than the economic threshold (lesions on third leaf below the ear leaf or higher on 50%) and if a susceptible hybrid was seeded. Under moderate disease pressure, timely fungicide applications can greatly minimize the impact on yield.

Northern Corn Leaf Blight

New northern corn leaf blight lesions can produce spores in as little as 1 week, allowing northern corn

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leaf blight to spread much faster than many other corn leaf diseases. Spores of the fungus are spread by wind and rain splash. Northern corn leaf blight is caused by the fungus *Exserohilum turcicum*, previously called *Helmithosporium turcicum*. The fungus overwinters as mycelia and conidia on corn residues left on the soil surface. During warm, moist weather in early summer, new conidia are produced on the old corn residue, and the conidia are carried by the wind or rain to lower leaves of young corn plants. Infection by germinating conidia occurs when free water is present on the leaf surface for 6- to 18-hours and the temperature is between 65°F and 80°F. Lesions develop within 7-12 days. Secondary spread within fields occurs by conidia produced on the leaf tissues. Conidia can be carried by wind over long distances where infection can occur in other fields. In this case, lesions may develop in the mid- to upper canopy.

The symptoms associated with northern corn leaf blight are often referred to as cigar-shaped lesions (Fig. 47.8). They are typically 1- to 6-inches long, gray-green to tan-colored, and often observed on the lower leaves. As the disease develops, the lesions spread to all leafy structures, including the husks. The lesions may become so numerous that the leaves are eventually destroyed causing major reductions in yield due to lack of carbohydrates available to fill the grain. The leaves then become grayish-green and brittle, resembling leaves killed by frost. Yield losses can reach as high as 30-50% if the disease establishes itself before tasseling.

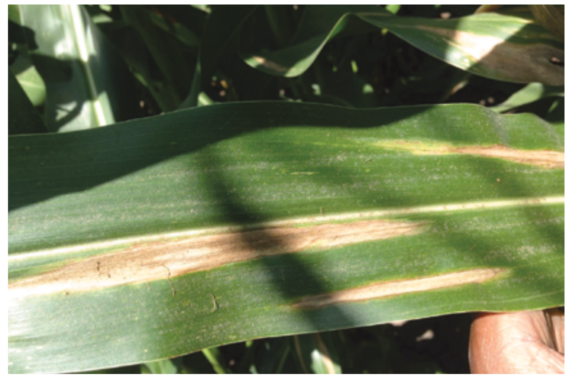

Figure 47.8 Northern corn leaf blight symptoms. Note the "cigar" shape of the lesion. (Courtesy of Emmanuel Byamukama)

Management systems that leave corn residues on the soil surface can have a high risk of this disease. The fungus prefers wet areas in production fields. Hot, dry weather slows disease growth. Management for northern corn leaf blight includes:

1. Planting resistant hybrids to northern corn leaf blight. This is the most effective form of northern corn leaf blight control.
2. Utilizing fungicide application when warranted. Numerous fungicide trials across the Midwest have found that products that contain a triazole are usually more effective than those that do not contain this chemistry.
3. Practicing crop rotation. Rotating away from corn helps to reduce the inoculum level in the field. The longer the rotation, the more benefits from rotation.

Physoderma Brown Spot

Physoderma brown spot is of minor importance on corn in South Dakota but occasionally can develop in corn when rainfall is abundant in spring and the mean temperature is high (73-86°F). Physoderma brown spot is caused by the fungus *Physoderma maydis*. The fungus overwinters as thick-walled sporangia in infected tissue or soil that germinate under moisture and light to produce zoospores. Zoospores swim in water and when in contact with leaf surface of young corn leaves, infection is initiated. Corn plants are most susceptible 50- to 60-days after germination and they become resistant with age. Standing water in the leaf whorls for at least 24 hours and high temperatures are required for infection to take place.

Corn plants infected with Physoderma maydis develop very small oblong to round, yellowish spots on lead blade, leaf sheath, stalk, and sometimes on the outer ear husk and tassels. Infected tissues turn chocolate brown to reddish brown and coalesce to form large irregular blotches. Stalks infected at the nodes beneath the sheaths often break and result in heavy lodging (Fig. 47.9)

This disease can survive for 3 years on corn residue and in soil. Management should include the use of crop rotations to reduce inoculum, and the use of tillage to bury crop residues.

Figure 47.9 (a) Physoderma leaf spot symptoms on a corn leaf. (b) Damage caused by Physoderma infection on the stalk rind. (c) Corn stalk lodging on the second node caused by Physoderma infection early in the season. (Courtesy: Alison Robertson [a, b]; Emmanuel Byamukama [c])

Fungal Stalk Rots

Stalk rots are among the most common and damaging of the corn diseases. Yield losses (5-20%) result from premature plant death and lodged plants. Stalk rot diseases are primarily caused by fungi that commonly occur in the field. Typical stalk rot symptoms include wilting plants with leaves that turn color (gray or brown), pith discoloration (lower internodes of the plant darken to tan or brown), and roots that may decay.

Anthracnose Stalk Rot

Figure 47.10 (a) Outer anthracnose stalk rot symptoms. (b) Corn plants killed by anthracnose stalk rot. (Courtesy of Alison Robertson, ISU)

Anthracnose stalk rot of corn is caused by the fungus *Colletotrichum graminicola*, which overwinters on infested corn residues (leaves and stalks). This is the same fungus that can cause anthracnose leaf blight (see description above). However, presence of the leaf blight phase does not necessarily lead to stalk rot phase. The fungus produces reproductive structures, called acervuli, which contain setae (porcupinelike structures). Conidia, fungal reproductive spores, are produced in large quantities in the acervuli and infect new plants. Splashing rain and wind carry the conidia spores to young corn plants where primary infection takes place. Disease development is favored by warm, moist weather (70-85°F) and high humidity. Anthracnose stalk rot is one of the most important stalk rot diseases in the United States.

The symptoms for anthracnose stalk rot are stalks that often have shiny, black lesions on the stalk's outer rind (Fig. 47.10).

Anthracnose stalk rot management should include:

1. The use of resistant hybrids. If available, resistant hybrids are effective at managing anthracnose stalk rot.
2. The use of a balanced soil fertility program. Ensure optimal levels of nitrogen (N) and potassium (K) are maintained in the soil.
3. Consider lowering the plant populations. High plant populations tend to have an increased severity of stalk rots.

4. Tillage to reduce surface residues. Burying crop residues can reduce the fungus survivability in the soil.
5. Control foliar diseases. High foliar disease severity may weaken the stalk making it more prone to stalk rot development.

Charcoal Rot

This pathogen also causes stalk and stem rot of alfalfa, sorghum, and soybean. Although this disease has been found on corn in South Dakota, its incidence and severity remain very low.

Figure 47.11 Charcoal rot on corn. (Courtesy of Jason Brock)

Charcoal rot is caused by the fungus *Macrophomina phaseolina*, and it is often called the dry weather wilt. Charcoal rot typically affects prematurely senescing plants that are under drought stress. Disease development is ideal when soil is dry and soil temperatures are 90°F or higher. The signs of charcoal rot include sclerotia, which are tiny, black, round, survival structures produced by this fungus (Fig. 47.11). When sclerotia are produced inside the stalk it gives the appearance of charcoal dust (hence how this disease got its name). Rotating the field into soybeans may not help with disease control because soybeans generally support a higher microsclerotia population than corn. Seed treatments may not be effective against this disease.

Management should include the use of resistant hybrids, if they are available, and adjusting planting date to coincide with greater moisture availability.

Diplodia Stalk Rot

Diplodia used to be one of the most common and damaging stalk rots found in corn, but now anthracnose and Fusarium stalk rots have increased in incidence and exceed Diplodia in the Midwest. Corn is the only host of this pathogen. Infection is favored by wet, warm conditions shortly after pollination.

Figure 47.12 Diplodia stalk rot. (Courtesy of Alison Robertson)

The fungus, *Diplodia maydis* (also known as *Stenocarpella maydis*), causes both Diplodia stalk and ear rot of corn. The fungus overwinters on crop residue. Conidia (produced in the pycnidia) can be splashed onto other areas of the plant. Infection at the nodes below the ear results in stalk rot, whereas infection of the silks and husks will cause ear and kernel rot. Injury by birds and insects also favor infection.

The symptoms for Diplopia stalk rot are wilted plants with shredded pith tissues. On the outside of the stalk, minute, dark brown/black pycnidia (reproductive structures) are embedded in the rinds (Fig. 47.12). The pycnidia feel rough and cannot be easily dislodged from the surface (unlike the perithecia in Gibberella stalk rot). Infected plants may have stalks that are easily broken. Diplopia stalk rot can result in low test weights, high harvest losses, and reduced harvest speeds.

Management should include: 1) the planting of corn hybrids with corn borer resistance and high scores for stalk strength as planting these hybrids minimizes wounds caused by insects; 2) crop rotation and tillage to reduce corn residue on the soil surface, and a 3) balanced fertility program.

Gibberella Stalk Rot

Gibberella stalk rot is one of the most common stalk rots in the corn belt. Gibberella stalk rot is caused by the fungus *Gibberella zeae*, which is called *Fusarium graminearum* in its asexual stage. This fungus is also a common seedling pathogen of corn and soybeans, and the causal pathogen of Fusarium head blight (scab) of wheat, barley, oat, and rye. The symptoms are a pinkish-red discoloration of the inside the cornstalk (Fig. 47.13). Perithecia (reproductive structures) may be observed on the surface of the stalk rind as small, round, black specks often near a node and are easily scratched off. Perithecia overwinter on the crop residue and act as the primary inoculum for the next growing season. This pathogen causes both ear rot and stalk rot of corn. Disease development is favored by warm, wet conditions. Stalk breakage and lodging often occur due to this disease. To manage Gibberella stalk rot, plant hybrids with good stalk strength and corn borer resistance, rotate crops, control the surface residues, use management practices that minimize yield limiting factors, and schedule harvest based on stalk strength.

Figure 47.13 Gibberella stalk rot. (Courtesy of Emmanuel Byamukama)

Fusarium Stalk Rot
Fusarium stalk rot is one of the most difficult diseases to diagnose. This pathogen is usually suspected after the diagnostic characteristics of the other stalk rot pathogens have been ruled out. This fungus infects sorghum, sugarcane, wheat, cotton, pineapple, and tomato. It overwinters on the infected surface residues. Corn borer adults can spread the disease in the cornfield.

Fusarium stalk rot is caused by many different Fusarium species, including *F. verticillioides*, *F. proliferatum*, and *F. subglutinans*. Fusarium stalk rot is favored by dry weather prior to silking and warm, wet weather after silking. The symptoms are white fungal growth on the outside of the stalk (Fig. 47.14). Infected plants may have poor kernel quality and test weights.

Figure 47.14 Fusarium stalk rot on a corn plant (left) compared with a healthy plant (right). (Courtesy of Emmanuel Byamukama)

The management for Fusarium stalk rot includes using a hybrid with good stalk strength and disease resistance, crop rotation, tillage to facilitate the breakdown of crop residues, planting at an appropriate seeding rate, soil tests, and application of appropriate amounts of K and N, insect control, and scouting to assess stalk conditions. If conditions are favorable for stalk rot development, field scouting is critical for determining which fields should be harvested first to avoid or minimize plant lodging and ear drop.

Scouting for stalk rots
The most common method used while scouting for stalk rots is the Push or Pinch Test. For this test, walk through a cornfield and randomly select a minimum of 100 plants representing a large portion of the field (10 plants at 10 random stops in the field). To test for stalk rot:

1. Push the plant tops approximately 30 degrees from vertical. If plants fail to snap back to vertical, the stalk has been compromised by stalk rot.
2. Pinch or squeeze the plants at one of the lowest internodes above the brace roots (pinching the same internode on each plant). If the stalks crush easily by hand, their integrity has been reduced by stalk rot.

If > 10% of plants exhibit stalk rot symptoms, harvest that field first to reduce the potential for plant lodging and yield loss.

Corn Ear Rots

Fungi cause several ear and kernel rots in corn that may result in yield loss, both in quantity and grain quality. In terms of quality, many ear rot pathogens also produce mycotoxins (see Chapter 46 on mycotoxins) that can affect feed value and marketability of the grain. Development of ear and kernel rots is enhanced by stalk lodging, and insect and bird injury. Weather also plays a major role in what type ear rot is likely to develop.

Gibberella Ear Rot

Gibberella ear rot, also called red rot, is quite common in corn especially under prolonged rainy weather late in the growing season. Its symptoms are characterized by a reddish mold that appears at the tip and grows down the ear (Fig. 47.15). If infected early, the entire ear may rot and be covered with a pinkish mycelium that causes the husk to tightly adhere to the ear. Gibberella ear rot is caused by *Gibberella zeae*. This pathogen overwinters on corn debris and has a wide host range including small grains. In wheat, this pathogen results in Fusarium head blight. The fungus infects the ear through silks and progresses down the ear. The disease is favored by cool, wet weather just after silking. Corn following corn is more prone to Gibberella ear rot development. This fungus produces mycotoxins (deoxynivalenol (DON) and zearalenone) in infected grain.

Figure 47.15 Gibberella ear rot on corn. (Courtesy of Emmanuel Byamukama)

This disease reduces yield, test weight, and storage life. If grain is contaminated with mycotoxins, it may be unsuitable for many uses. Management of this pest includes:

1. Select resistant hybrid, husk tightness and hybrids that dry-down rapidly.
2. Scout fields prior to harvest to identify high-risk areas.
3. Adjust the combine to minimize kernel damage.
4. Dry infected corn to 15% moisture or less.
5. Use residue management through tillage and rotation to reduce inoculum load.

Fusarium Ear Rot

Fusarium ear rot develops under hot dry weather and occurs at and after flowering. Infection can occur through the silks but damage by birds, insects, or hail increase chances of infection (Fig. 47.16). Several Fusarium species cause ear rot, but the most common species are *F. verticillioides* and *F. proliferatum*. These Fusarium species overwinter in corn residue from corn and other plants. The fungus infects corn ear through silk and wounds, and it can enter the ear through hail damage or wounds from feeding insects. Occasionally, Fusarium stalk rot can develop systemically and cause ear rot. These Fusarium species also produce mycotoxins (Chapter 46).

The symptoms vary greatly depending on the genotype, environment, and disease severity. Individual infected kernels can be scattered in the ear, and under severe conditions, the fungus may consume the entire ear. Infected kernels have whitish pink to lavender fungal growth.

Figure 47.16 Corn ear with Fusarium ear rot. (Courtesy of Alison Robertson)

This disease reduces yield and grain quality. The kernel can be completely consumed by fungus and be contaminated with mycotoxins (fumonisins), which can be fatal to livestock (horses and pigs). Management for this disease includes:

1. Selection of resistant hybrids. The relative rating should be based on previous history. If this has been a problem in past years, select hybrids with high scores for ear rot resistance.
2. The use of tillage and rotation to reduce pest populations and overwintering.
3. The control of insects that can cause wounds.
4. Store infected grain separately to avoid infecting the entire bin.
5. Dry grain to < 15% moisture if grain is to be stored through the next summer.

Diplodia Ear Rot

Diplodia ear rot develops in cornfields with history of this disease and when weather is wet and warm around the silking time. Diplodia ear rot is caused by *Diplodia maydis* (also known as *Stenocarpella maydis*). Infected corn residue is the main source of inoculum. Ears are most prone to infection about three weeks after flowering when the silk dies off. Conidia are spread through splashing rain during wet weather. Corn is the only known host of this disease. The infected ears have husks that appear bleached to straw-colored and can be seen from a distance with dead ear leaf. Unlike Gibberella ear rot, Diplodia ear rot starts at the base of the cob (47.17). Infected kernels are dull gray to brown. If infection occurs several days after flowering, the ears do not show external symptoms, but white fungal mycelium may be seen between the kernels.

Figure 47.17a Diplodia ear rot on corn. Notice the dead ear leaf. (Courtesy of Alison Robertson)

Figure 47.17b Corn ear with late Diplodia ear rot infection. Notice the white mycelia between kernels. (Courtesy of Emmanuel Byamukama)

This disease reduces yields, kernel size, and test weight. The management of Diplodia ear rot includes the selection of resistant hybrids. In fields with previous history of this disease, select hybrids with greater resistance.

1. The use of crop rotation and tillage to reduce inoculum.
2. Grain from infected fields should be dried to a moisture content < 15% as quickly as possible.
3. Grain from infected fields should be cleaned to remove damaged kernels.

Aspergillus Ear Rot

Aspergillus ear rot is most important ear disease because of the production of aflatoxins that are dangerous to humans and animals (Chapter 46). Two common species *Aspergillus flavus* and *A. parasticus* infect corn. Of these, A. flavus is the most predominant species. The fungus overwinters in the soil and debris and infection is favored by hot, dry weather. The fungus is spread to silk by wind or insects. This disease can be important under drought conditions. Insect damage predisposes the kernels to infection and consequent Aspergillus ear rot development. In most cases only a few kernels on an ear are infected. Infected kernels have masses of olive to yellow-green spores on and between them (Fig.47.18). Usually the tip of the ear is where infected kernels tend to concentrate but any other part of the ear may be infected. Sporulation of the fungus is most evident on kernels that were injured. However the fungus can also be present on kernels without showing symptoms.

If Aspergillus ear rot is present in a field, the grain needs to be tested for aflatoxins. If concentrations are > 20 ppb the grain cannot be sold or transported across state lines. The blending of corn to reduce concentrations is prohibited for interstate trade. If the grain is used for ethanol production, the distillers grain will have elevated aflatoxin levels. The risk of this disease can be reduced by:

1. Selecting appropriate hybrids. Most seed corn companies do not rate hybrids for Aspergillus ear rot resistance. Hybrids with good drought resistance should provide some protection.
2. Use management techniques that increase water use efficiency, such as a balanced soil fertility program, and seeding at appropriate rates and dates.
3. Control insects to prevent injury to ears.
4. Practice tillage to reduce the inoculum.
5. If the grain is harvested from infected fields, use techniques that minimize kernel damage, harvest the grain separately, screen the grain to remove broken kernels, control insects, and maintain low temperatures and moisture during storage.

Figure 47.18 Aspergillus ear rot symptoms. (Courtesy of Robertson Alison)

Bacterial Diseases

Bacterial diseases can be destructive if infections are severe and widespread. The selection of resistant hybrids and the use of other integrated pest management strategies are the cornerstones for controlling bacterial diseases. There are four bacterial diseases that occur on corn in South Dakota: Goss's wilt, Holcus leaf spot, bacterial stalk rot, and Stewart's wilt.

Goss's Bacterial Wilt and Leaf Blight

Goss's wilt has increased in occurrence in South Dakota. Continuous corn production especially under irrigation increases the spread of this disease. Additional hosts for this pathogen include green foxtail, shattercane, barnyardgrass, and other common grass species.

Goss's bacterial wilt and leaf blight of corn (Goss's Wilt) is caused by the bacterium *Clavibacter michiganensis* subsp. *nebraskensis*. The bacteria overwinter on infested crop residue on the soil surface from which they are splashed onto growing corn plants. The bacteria enter the plants either through their natural plant openings or wounds created by hail, heavy rainfall, sand blasting, high winds, and insect feeding. Disease development is favored by high humidity (moisture) and temperatures of 80°F.

The symptoms for Goss's bacterial wilt and leaf blight are foliar (leaf) blight (Fig. 47.19a) and a systemic wilt (Fig. 47.19b). Leaf blight is more common than systemic wilt. Lesions may be gray to tan in color with wavy, irregular margins that follow the leaf veins. The most obvious characteristics are the dark green to black water-soaked lesions often called "freckles" that appear on the infected area. Another characteristic of Goss's wilt is the bacterial ooze that may be found on the leaf surface. On the leaf surface, dry bacterial

Figure 47.19a Characteristic lesion of Goss's wilt showing the black freckles (arrows) within the lesion. (Courtesy of Emmanuel Byamukama)

Figure 47.19b Corn wilt caused by early infection of Goss's wilt bacteria. (Courtesy of Emmanuel Byamukama)

ooze may appear to shine and glisten in the sunlight. An easy technique to use when looking for the freckles is to use a lighted flashlight on the underside of the lesion or hold the leaf up to the sunlight so it is backlit. The dark freckles will appear translucent.

The risk of this disease is greater in corn-on-corn fields with high residues on the soil surface. The management of this bacterial disease includes:

1. The use hybrids tolerant of Goss's wilt. Check with your seed dealer for Goss's wilt ratings.
2. The use of rotations and tillage to reduce inoculum. Any type of tillage that buries infested residues and encourages residue decomposition will help reduce the inoculum level in the field. Rotating to a nonhost crop such as soybean, small grains, alfalfa, or dry bean will help reduce primary inoculum in the corn residues, but rotation will not completely eliminate the bacteria.
3. Control grassy weeds. Grassy weeds serve as additional hosts for Goss's wilt so weed control is important for disease control.
4. Fungicide applications are not effective against this bacterial disease. There are no in-season control measures available for the prevention or spread of Goss's wilt.

Holcus Leaf Spot

Holcus spot symptoms can resemble chemical injury to leaves, similar to paraquat drift. Holcus spot is occasionally observed in South Dakota and typically does not reduce yield or reduce grain quality. The pathogen is caused by a bacterium called *Pseudomonas syringae pv. syringae*, which overwinters in crop debris. Wounds caused by hail, blowing soil or wind can increase chances of infection. Warm (75-85°F), wet, windy conditions early in the season favor infection and the development of Holcus leaf spot. The pathogen has a wide host range including many grasses and dicots. It can have ice nucleating activity that may enhance frost injury to corn leaves. Holcus spot symptoms first appear as water-soaked, dark green lesions near the tips of lower leaves. They then develop into round or elliptical, tan to white spots that are 1/8 to ½" in diameter (Fig. 47.20). Red to brown margins develop around the spots, which may be surrounded by yellow halos. The management for this bacteria should include the use of crop rotations and tillage to bury the crop residue. The use of fungicides will not be effective against this bacteria.

Figure 47.20 Holcus spot in corn. (Courtesy of Emmanuel Byamukama)

Stewart's Disease or Stewart's Wilt

This disease is somewhat unique because its spread depends almost completely on an insect vector, the corn flea beetle. Stewart's wilt is occasionally observed in South Dakota. The use of seed treatment insecticides has reduced the occurrence of the disease. Infection occurs in plant tissues that are wounded during feeding by the corn flea beetle *(Chaetocnema pulicaria)*. The corn flea beetle is the overwintering host and vector of the bacterium Pantoea stewartii, formerly called *Erwinia stewartii*, the bacterium that causes Stewart's wilt.

There are two phases of Stewart's wilt that occur on corn: the seedling wilt phase (occurs when young plants are infected systemically) and the leaf blight phase (occurs when the plants are infected after the seedling stage). In either case, symptoms appear as leaf lesions originating from flea beetle feeding scars. The bacteria overwinter in the insect gut. Leaf tissue surrounding feeding wounds initially become water-soaked. Pale-green to yellow linear streaks with irregular or wavy margins develop parallel to leaf veins. These lesions become necrotic with age and may extend to the entire length of the leaf on susceptible cultivars. When plants are infected systemically, symptoms appear on new leaves emerging from the plant whorl, and cavities may form in the stalks near the soil line. Bacteria spread throughout the vascular system of infected plants and occasionally infect kernels.

Foliar symptoms of the leaf blight phase are similar to those of the seedling wilt phase. Chlorotic or necrotic tissues may extend the entire length of leaves, or symptoms may be limited to a few inches depending on the susceptibility of the cultivar. Premature leaf death due to Stewart's wilt may predispose the weakened plant to stalk rot resulting in reduced yields.

The bacteria will reduce yields for several reasons. First, early season infection reduces the plant population. Second, the disease reduces leaf area and sugar production, and consequently, the risk of stalk rot is increased. Management for this disease includes:
1. The use of resistant varieties. Stewart's wilt is controlled effectively by planting resistant corn hybrids.
2. The control of corn flea beetles. This should include scouting and the application of appropriate insecticides, if needed.
3. Use of pathogen-free seed. The bacterium can be excluded from areas where it does not already occur by ensuring that the seed is pathogen-free.
4. Fungicides are not effective against this bacterial disease.

Bacterial Stalk Rot

Bacterial stalk rot typically develops midseason rather than at the onset of senescence. It is more common in irrigated corn when an open well as the source of irrigation water. Bacterial stalk rot is caused by the bacterium *Erwinia chrysanthemi pv. zeae*. Infection is associated with warm temperatures (90-100°F) and high humidity. This pathogen overwinters only in stalk tissues above the soil surface. Infection can initially take place at the top or bottom of the plant. Early symptoms consist of plant lodging and dark brown, water-soaked lesions that progress to soft or slimy stalk tissues, which appear at stalk internodes located above the ground (Fig. 47.21). A foul odor often accompanies infected plant tissues. The management for bacterial stalk rot should include the use of tillage to bury surface residues and soil drainage to reduce disease incidence. Fungicides are not effective against this disease.

Figure 47.21 Bacterial stalk rot symptoms on corn. This disease affects the top part of the plant. (Courtesy of Emmanuel Byamukama)

Corn Nematodes

Corn nematodes are microscopic, unsegmented roundworms that either feed inside the corn roots (endoparasites) or feed outside the corn roots (ectoparasites). Nematodes feed on root cells by puncturing the cell walls with their hollow stylets, which resemble minute hypodermic needles. Nematodes cause yield losses in corn in two ways: directly, by injuring cells and using up cell metabolites; and indirectly, by creating wounds that become entry points for bacterial, fungal, and viral pathogens. Over a dozen nematodes have been found to infect corn in South Dakota and the extent of yield loss will depend on the type of nematode, the population density in the soil, soil type (sandy soils tend to support high population densities of certain nematodes), and other stresses such as fertility and moisture stress. The most common groups of plant parasitic nematodes found on corn are lesion (Pratelenchus), dagger (Xiphinema), lance (Hoplolaimus), needle (Longidorus), stubby root (Trichodorus and Paratrichodorus), and stunt (Tylenchorhynchus) nematodes.

Figure 47.22 Severe damage caused by sting nematodes on corn. (Courtesy of Tamra Jackson Ziems)

Although several nematodes can be found infecting corn, few are of major concern in South Dakota. However, producers are encouraged to sample and test soil from low-yielding spots for corn nematodes.

Diagnosis of nematodes should not be based solely on plant symptoms because these can be caused by other problems such as low fertility, poor drainage, drought, herbicide injury, or other pathogens, including fungi and viruses. Under high nematode population density, the following symptoms may be displayed:

- Stunted plants and uneven plant height along the rows (Fig. 47.22).
- Yellowing of plants.
- Poor ear fill.
- Root necrosis and stubby roots (Fig. 47.23).

Figure 47.22 Severe damage caused by sting nematodes on corn. (Courtesy of Tamra Jackson Ziems)

Management for corn nematodes includes:

1. Test soil for corn nematodes, especially if corn plants are stunted, yellowing (Fig. 47.22.), and have necrotic roots. Carefully dig up affected corn plants and send them to the South Dakota State University Plant Diagnostic Clinic for nematode extraction before corn reaches the V6 stage of development.
2. Practice crop rotation to check or reduce nematode population density.
3. Use nematicide seed treatment in areas where nematode population density is high. Though several reports show no consistent yield benefit with a nematicide seed treatment in corn, these may reduce high nematode population densities.
4. Avoid plant stress. Use proper fertility management, drainage, and weed control.

Viral Diseases

There are three viruses that are occasionally found infecting corn in South Dakota: wheat streak mosaic virus (WSMV), maize dwarf mosaic virus (MDMV), and brome mosaic virus (BrMV). Viruses are obligate pathogens that cannot be grown in artificial culture, cannot be seen with the naked eye, and must always pass from living host to living host in what is referred to as a "living or green" bridge. Managing corn viruses requires that the living bridge of hosts be broken. Fungicides and bactericides cannot be used to manage viral problems in corn.

Wheat Streak Mosaic Virus

Wheat streak mosaic virus (WSMV) was first observed in Nebraska in 1922. WSMV has been observed in varying degrees in South Dakota. WSMV is the most important endemic (always here, but varies in amount) viral disease in wheat but it rarely is observed or causes measureable yield loss in corn. The pathogen causing this disease is Wheat streak mosaic virus (WSMV). WSMV is transmitted by the wind-blown wheat curl mite (Aceria tosichella Keifer). Both the mites and virus survive South Dakota winters on seeded and volunteer winter wheat and perennial grasses. Corn serves as a host for the mites after wheat harvest until a new crop of wheat emerges. The symptoms for wheat streak mosaic virus include a red streak in the kernel (Fig. 47.24). This streak is a response to a toxin that is found in the mites' saliva. The management of wheat streak mosaic virus includes:

Figure 47.24 Red stripe on kernels caused by a toxin produced by wheat curl mites. (Courtesy of Emmanuel Byamukama)

1. The control of grassy weeds and volunteer wheat. Break the living bridge by controlling the grassy weeds and volunteer winter wheat. This prevents the mites from spreading the virus as the mites and virus cannot survive more than a day without a living host.
2. The use of resistant varieties/cultivars. If planting wheat, use the most tolerant/resistance cultivars/ hybrids available in your area.

Maize Dwarf Mosaic Virus

Maize dwarf mosaic virus (MDMV) is rarely observed in South Dakota. MDMV is vectored by many species of aphids, most commonly the corn leaf aphid, the greenbug, and the green peach aphid. MDMV can also infect Johnson grass and sorghum. The symptoms include small, chlorotic spots that are observed on green, young leaves that later develop into a mottle or a mosaic pattern along the veins of leaves, leaf sheaths, and husks. As infected plants continue to grow and the temperature rises, the mosaic symptoms may disappear while the young leaves become more yellow. Plants may be stunted, excessive tillering may occur, and poor seed set may take place. Management should include the use of tolerant hybrids, the control of the insect vector, and the control of Johnson grass.

Figure 47.25 A close-up of brome mosaic virus symptoms. Notice the chlorotic mosaic streaks on the corn leaf. (Courtesy of Emmanuel Byamukama)

Brome Mosaic Virus

Brome mosaic virus (BrMV) is transmitted by nematodes in the Longidoridae family. BrMV infects several grass species, and tillage along the field edges may move nematodes to the field. This virus is not common, but sometimes corn plants near field edges can be infected. Infected plants are stunted and leaves have mosaic, chlorotic streaks on the entire leaf (Fig. 47.25). Infection is systemic (throughout the entire plant) and infected plants do not produce an ear (Fig. 47.26). Sometimes infected plants die or are outcompeted by healthy plants. BrMV can be managed by using tolerant hybrids, avoiding movement of soil from the field edges, and controlling grassy weeds especially at the field edges.

Figure 47.26 A stunted corn plant infected with brome mosaic virus between healthy plants. Such plant will not produce any ears. (Courtesy of Emmanuel Byamukama)

References and Additional Information

Websites

- https://www.pioneer.com/home/site/ca/agronomy/crop-management/corn-insect-disease
- http://ipm.missouri.edu/ipm_pubs/ipm1001.pdf
- http://fyi.uwex.edu/fieldcroppathology/files/2010/09/Corn_Foliar_Disease_Cards.pdf
- https://cropwatch.unl.edu/archive/-/asset_publisher/VHeSpfv0Agju/content/corn-disease-update-%E2%80%94-leaf-and-bacterial-diseases-developing

Paper and Manuals

Clay, D.E., S.A. Clay, and K. Reitsma. 2009. South Dakota Corn Best Management Practices. SDSU, Brookings, SD.

Shurtleff, M. C. Edwards, D. I. Noel, G. R. Pedersen, W. L. and White D. G. 1993. Diseases of Corn or Maize. Available at: http://www.apsnet.org/publications/commonnames/Pages/CornorMaize.aspx (accessed 7 June 2016).

White. D. G. 1999. Compendium of Corn Diseases. American Psychopathological Society Printing Press, Minneapolis, MN. 78pp.

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