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CHAPTER 7

Corn Diseases and Nematodes

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Several diseases are economically important for corn production in Arkansas. Most of the major corn diseases are foliar – meaning they affect the leaves – which vary from year to year because they are strongly influenced by weather conditions. Thus, accurate identification and an awareness of potential disease losses are essential for continued successful corn production. Seedling disease, southern rust, northern corn leaf blight, stalk rots and aflatoxin contamination are among the most common corn diseases in the state. The following symptoms and photographs of common and occasionally occurring diseases should help producers facilitate identification and make sound management decisions regarding these diseases before they become a yield-limiting problem. If you need assistance in diagnosis of a disease, contact your local county Extension agent or the Plant Health Clinic.

Bacterial Diseases

Bacterial stalk rot is generally a minor disease in the state and occasionally occurs after extended periods of warm and wet weather.

Symptoms – Bacterial stalk rot is caused by *Erwinia chrysanthemi* that infects and decays the internode region of a stalk at one or two internodes above the soil surface. The rotted area may appear water soaked to tan or dark brown in color and often has a pungent odor. Stalks typically twist and lodge (Figure 7-1) but remain green for a few weeks until the vascular tissue is completely compromised. Extended periods of heavy rainfall in poorly drained soils and high temperatures (90° to 95°F) favor disease development. Bacterial stalk rot is often mistaken for Pythium stalk rot, which is caused by a fungal pathogen, because it, like Pythium stalk rot, occurs earlier than other fungal stalk rots. An indication that bacterial stalk rot is the cause, however, is that bacterial stalk rot often exudes a foul odor when compared to Pythium stalk rot (see later in chapter).

Figure 7-1. Lodged corn plant caused by bacterial stalk rot.

Management – Management of bacterial stalk rot is typically not necessary, but in areas where stalk rot has been confirmed, consider planting hybrids with good stalk strength to minimize lodging. Incorporate previous crop residue to reduce bacterial survival and follow recommendations for fertility and plant populations.

Damping-Off and Seedling Blights

Seed rots and **seedling blights** are usually not widespread but occur in localized areas. These diseases can cause significant stand loss in poorly drained, excessively compacted, cold and/or wet soils.

Symptoms – Seeds may rot and die prior to emergence (pre-emergence damping-off) or die shortly after emergence (post-emergence damping-off). Seedling blight symptoms consist of soft rotting of the emerging stem tissue at or below the soil line that result in yellow leaf tissue that wilts and dies (Figure 7-2). Numerous soilborne fungi (e.g., *Pythium, Fusarium, Penicillium,* etc.) can cause damping-off and seedling blights.

Figure 7-2. Seedlings with varying degrees of post-emergence damping-off severity caused by F*usarium.*

Management – Plant quality, fungicide-treated seed into warm soil (consistently above 55°F) with sufficient moisture for rapid seedling emergence. Generally, fungicide-treated seed provides 10 to 20 days of protection against seed rots.

Foliar Fungal Diseases

Southern corn leaf blight (SCLB) was considered a minor disease with little economic importance until 1970 when it caused an epidemic across the Corn Belt. SCLB destroyed 15% of the U.S. corn crop with an estimated value of one billion dollars. Later, it was determined that a new strain (race T) of the fungus produced a toxin (T-toxin) which was highly aggressive on corn hybrids with the Texas male-sterile cytoplasm (cms-T). In 1970, the majority (~85%) of the U.S. corn hybrids contained cms-T. Today, resistant corn hybrids are used to manage this disease.

Symptoms – Leaf lesions vary in shape, color and size among hybrids, but are generally oval to elongated, tan-colored lesions with a yellow-green border (Figures 7-3 and 7-4). Lesions are commonly observed on the leaves in the lower canopy, but may occur on sheaths, stalks and husks of susceptible hybrids.

This disease is caused by the fungus *Bipolaris (Helminthosporium) maydis*, which infects many other grasses. There are three physiological races

Figure 7-3. Southern corn leaf blight on a susceptible commercial hybrid.

Figure 7-4. Progressive symptoms of southern corn leaf blight on a susceptible hybrid.

of *B. maydis*: race O, race T and race C. Only races O and T have been reported in the U.S. The fungus overwinters in the soil and crop debris. Spores are produced by the pathogen, which can be disseminated by wind over long distances. Infection can also occur from rain splashing spores from the soil onto nearby plants. Warm (86° to 90°F), wet weather conditions favor disease development. The disease cycle can be completed within 2 to 3 days with favorable conditions, thus this disease can spread very rapidly.

Management – Use of resistant hybrids is the most practical and effective method to control SCLB. Tillage along with a one-year crop rotation with a non-host crop can reduce the overwinter pathogen survival on crop residue. Though fungicides are effective (see the Extension publication MP154, *Arkansas Plant Disease Control Products Guide*, at www.uaex.uada.edu), they are rarely nee ded for SCLB in Arkansas

Northern corn leaf blight (NCLB) is one of the more common foliar diseases of corn in Arkansas. As with most foliar diseases timing of infection is critical to yield loss. When infection occurs before silking, yield losses of 50% can occur. Yield losses are minimal when infection occurs after dough or dent growth stages.

Symptoms – NCLB is caused by the fungus *Exserohilum turcicum*, which can also infect grain sorghum and forage sorghums. Leaf lesions are large (1 to 6 inches), gray-green in color and cigar-shaped (Figure 7-5). Mature lesions are tan with dark zones of spores produced by the fungus. Leaf lesions vary in size and shape among hybrids, with larger lesions produced on susceptible hybrids. The fungus overwinters on corn stalk stubble and debris, thus NCLB most commonly occurs in fields with minimum tillage and frequent or continuous corn production. In the spring when conditions are favorable, the pathogen produces spores that are dispersed onto nearby plants or disseminated by wind to another field. Lesions can produce spores within a week, thus secondary infections can occur quickly (Figure 7-6). Disease development is favored by moderate temperatures (64° to 81°F) and prolonged periods of leaf wetness provided by heavy dew or extended periods of rainfall.

Figure 7-5. Several northern corn leaf blight lesions on a susceptible hybrid.

Figure 7-6. Severe symptoms of northern corn leaf blight on a susceptible hybrid. *Photo by J. Smith*

Management – Resistant hybrids are available and are the most economical way to manage NCLB. There are four known single dominant resistance genes, *Ht1, Ht2, Ht3* and *HtN*, that are used in corn to develop hybrids with resistance to NCLB. Resistance is expressed as chlorotic lesions that support limited sporulation or slow disease development with a long latent period (time from infection to lesion development) and fewer, smaller lesions. Cultural practices that may minimize disease severity include crop rotation and tillage to hasten the decomposition of corn residue and subsequent survival of the pathogen on crop residue.

Currently, there are no fungicide thresholds specifically for NCLB management; however, researchers have determined it is important to protect the ear leaf and upper leaves as the plant matures through the reproductive stages of growth. Fungicide thresholds are complicated by the differences among hybrid susceptibility to NCLB, time required for infected corn to reach physiological maturity (i.e., black layer), and most importantly, unpredictability in forecasting the weather. As a general guideline, consider a fungicide on susceptible hybrids when there is at least one lesion on 50% of the plants prior to or near VT/R1, AND weather conditions favor disease development. Weather conditions that are favorable for NCLB development are moderate temperatures (64° to 81°F) with several days of light rain of heavy dew. Hot and dry weather will suppress NCLB development. See the publication MP154 for fungicides labeled for use on corn in Arkansas.

Gray leaf spot is a common foliar disease in warm, humid environments but occurs less frequently than NCLB or southern rust in Arkansas. When it has been observed in the state it is most frequently in the northeast corner.

Symptoms – Immature lesions that develop early in the season are small necrotic spots that may have a yellow halo. Because gray leaf spot is often difficult to distinguish from other foliar corn diseases, it is recommended that suspicious samples be sent to the Arkansas Plant Health Clinic in Fayetteville for proper identification. Mature lesions are tan to gray and expand linearly between leaf veins giving a rectangular shape (Figure 7-7).

Figure 7-7. Numerous rectangular lesions caused by gray leaf spot.

Gray leaf spot is caused by the fungus *Cercospora zeae-maydis*. This fungus overwinters in crop residue that remains on the soil surface. In the spring, spores are produced that are dispersed by wind and splashing rain onto nearby corn. Disease development is favored by warm (72° to 86°F), humid (high humidity or leaf wetness) weather conditions.

Management – Resistant hybrids are available and should be considered in minimum tillage systems. In fields with a history of gray leaf spot, conventional tillage practices that promote stubble decomposition and rotating out of corn for at least one season is recommended. Foliar fungicides may be economically beneficial on susceptible hybrids to protect high yield potential under prolonged weather conditions that favor disease development. See MP154 for current fungicide recommendations.

Anthracnose leaf blight can occur on leaves at any growth stage, but is most commonly observed on the lower leaves of developing seedlings with little or no further disease spread until after tasseling.

Symptoms – Leaf lesions begin as small water-soaked lesions that may enlarge up to ½ inch with tan to brown centers and yellowish to reddish-brown borders. Lesions may coalesce, killing large leaf areas or entire leaves of susceptible hybrids. Lesion size can vary depending upon hybrid, making diagnosis in the field difficult. The fungal fruiting bodies (acervuli) develop abundantly on dead tissue and can typically be seen with the aid of a hand lens. Dark black spines (setae) can often be observed protruding from these fungal fruiting bodies (Figure 7-8).

Anthracnose leaf blight of corn is caused by the fungus *Colletotrichum graminicola*. The fungus overwinters on crop reside left on the soil surface. In the spring, spores are produced that are dispersed by wind and splashing rain onto nearby plants. Anthracnose is favored by warm temperatures, heavy dew and long periods of cloudy, wet weather.

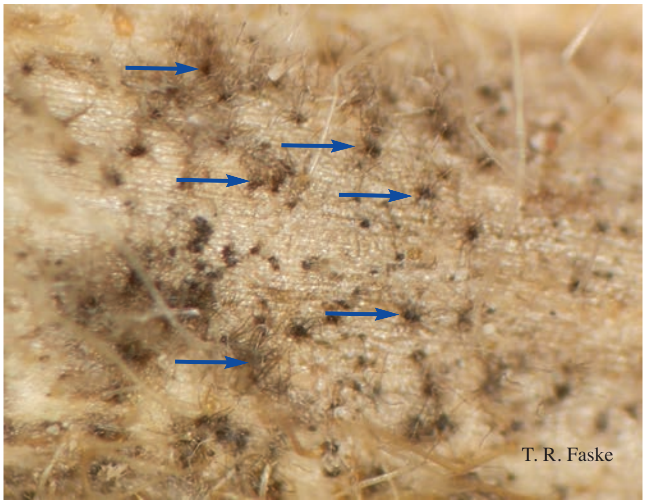

Figure 7-8. Setae protruding from several *Colletotrichum* fruiting bodies. Blue arrows indicate a few of the acervuli-producing setae.

Management – Use of resistant hybrids is the most economical management practice; however, hybrids resistant to anthracnose leaf blight may not be resistant to anthracnose stalk rot (see later in chapter). Hybrids with good stalk strength, yield potential and resistance to the anthracnose leaf blight should be selected. Since anthracnose overwinters in corn residue, complete burial of residue and one-year rotation from corn will significantly lower in-field inoculum. Avoid plant stress by using a balanced soil fertility program. Though fungicides are effective (see MP154), they are not commonly needed for early-season control of anthracnose in Arkansas.

Crazy top is occasionally observed in Arkansas, usually in isolated areas where corn was planted in wet, poorly drained areas of the field.

Symptoms – Symptoms vary depending on time of infection and degree of pathogen colonization of the developing plant. Symptoms consist of excessive tillering (6 to 10 tillers/plant), stunting, yellow to whitish striped leaves or leathery leaves. The most striking symptom occurs at tasseling when the tassel develops a twisted, leafy appearance that may resemble tiny ears (Figure 7-9). Crazy top is almost always associated with low-lying areas, drainage patterns, or sustained saturated soils.

Figure 7-9. Excessive proliferation of a corn tassel caused by crazy top.

Crazy top is caused by the soilborne fungus *Sclerophthora macrospora*, which can infect other grain crops like oat, wheat, sorghum and rice as well as many other grass species. In saturated or waterlogged soils the fungus produces motile spores (zoospores) from thick-walled overwintering spores (oospores). Once the motile spores are active they can infect young plants (before the 5-leaf stage) within 24 to 48 hours. After infection, the fungus grows within the plant, causing a variety of symptoms. Infected plants typically do not produce grain

Management – Plant corn in fields with good drainage that are not prone to sustained flooding. Prolonged flooding early in the season predisposes corn to infection. It is also recommended that grassy weeds be controlled because they may also be a reservoir for the pathogen.

Banded sheath blight is frequently observed in isolated areas of the state when frequent rainfall occurs during the growing season. This disease may cause some lower leaves to wilt and die, but rarely moves up the stalk, thus it is considered a minor disease of corn, rarely causing any yield loss.

Symptoms – Bands of gray or brown discolored areas are visible on lower leaves and sheaths of infected corn plants. Large (size of a BB), brown spherical sclerotia can be found on symptomatic corn stalks (Figure 7-10). Symptoms and signs (sclerotia on lower stalk) are often observed from early reproductive stages through grain fill.

Banded sheath blight is caused by the soilborne fungus *Rhizoctonia solani* AG1, which also causes aerial blight of soybean and sheath blight of rice. Given the pathogen is soilborne, banded sheath blight is most commonly observed in fields with a history of these diseases. The pathogen overwinters as sclerotia in the soil and mycelium on crop residue. Infection occurs during the late vegetative stages of growth on corn leaves in the lower canopy with symptoms being detected during early- to mid-reproductive stages. Frequent rainfall that contributes to prolonged conditions of high relative humidity and warm temperatures (70° to 90°F) favor disease development.

Management – Management of banded sheath blight is typically not necessary, but in areas where the disease is confirmed, consider planting hybrids with good stalk strength that are less susceptible to lodging. Given the wide host range of the pathogen, crop rotation typically sustains rather than reduces inoculum levels in the field. Fungicides are not recommended to manage banded sheath blight because it traditionally causes no yield loss. Furthermore, sufficient fungicide coverage needed to control sheath blight in the lower canopy is difficult with the normal spray volume used for most foliar corn diseases.

Figure 7-10. Banded sheath blight on lower corn leaves and sheath. Note large brown sclerotia produced by *Rhizoctonia solani* on infected leaves.

Common rust has been reported in all corn production regions of the United States and is very common in Arkansas, but it has no significant impact on yield. Summer weather conditions in the South do not favor common rust development.

Symptoms – Common rust is caused by the fungus *Puccinia sorghi*, which infects corn, not sorghum as the scientific name suggests. Pustules of common rust are circular to elongate, golden brown to cinnamon brown in color (Figure 7-11) and are found on upper and sporadically on lower leaf surfaces (Figure 7-12). As the pustule matures, cinnamon brown urediniospores are replaced by golden brown to black teliospores, which cause the pustules to darken to a brownish-black.

Figure 7-11. Common rust of corn.

Figure 7-12. Common rust pustules on upper and lower corn leaf surfaces. Note the occasional sporulation on the lower leaf surface.

Rust spores are windblown from the tropic regions of Mexico where the rust fungus overwinters on *Oxalis* spp., a genus in the wood-sorrel family. During the growing season, spores move progressively northward from southern states. Conditions that favor infection consist of moderate temperature (61° to 77°F) and high relative humidity (>95%). At least 6 hours of free moisture are required for common rust spore germination and infection. The latent period is 7 days with optimum conditions for disease development. Common rust is typically found in the lower canopy (1 to 2 feet from the ground), and younger leaves are more susceptible than fully expanded mature leaves.

Management – Resistant hybrids are effective and available; however, environmental conditions during the summer are often unfavorable for common rust to be a significant disease. Fungicides are effective, but not economically practical to manage common rust.

Southern rust is one of the most important foliar corn diseases in Arkansas. This rust does not overwinter in the state and must be reintroduced each year from Southern states. When southern rust arrives late in the growing season on dough or dent growth stages, it causes minimal losses. However, the risk of yield loss is much higher when infection occurs at tasseling or silking.

Symptoms – Southern rust is caused by the fungus *Puccinia polysora*, which only infects corn. Pustules of southern rust are small (0.2 to 2 mm in diameter), circular to oval and light cinnamon brown to orange (Figure 7-13). They frequently form on the upper leaf surface and very rarely on the lower leaf surface (Figure 7-14). Southern rust pustules may occur on leaves, stalks, sheaths, and husks (Figure 7-15).

Figure 7-13. Severe symptoms of southern rust on a susceptible hybrid.

Figure 7-14. Single pustule of southern rust on upper and lower corn leaf surfaces. Note the absence of fungal sporulation on the lower corn leaf surface.

Figure 7-15. Southern rust on corn leaf, sheath and collar.

Rust spores are windblown from areas south of Arkansas and move progressively northward during the growing season. Southern rust is easily overlooked by the casual observer early in the season because initial infections are typically only one to two pustules per plant (Figure 7-14). The absence of sporulation on the lower leaf surface early in the season is an indication of southern rust. As indicated earlier, rust sporulation on the lower leaf surface is associated with common rust, a minor disease. Early-season southern rust pustule development is most frequently observed in the field at mid-canopy (4 to 5 feet from the ground) along the edge of the field. Free moisture as dew or light rain is necessary for rust spores to germinate and infect. Symptoms appear about 3 to 6 days after infection, and by 7 to 10 days the pustules may rupture to expose more rust spores. Thus, new infections can occur very rapidly after the initial infection when conditions favor disease. Conditions that favor disease development consist of high temperatures (80° to 90°F), high relative humidity and frequent rainfall/heavy dew. Even in hot summer conditions with temperatures above 100°F, pustules continue to sporulate, hence the name southern rust.

Management – Corn hybrids vary in susceptibility to southern rust; therefore, planting the least susceptible hybrid is recommended. Typically, southern rust arrives in late June or early July, so early-planted corn may avoid significant rust development and yield loss. It is a good idea to budget a fungicide into the production cost for late-planted corn (typically for May-planted corn). Fungicides are effective at suppressing southern rust. There is no economic threshold for a fungicide application, because fungicide action thresholds are complicated by the differences among hybrid susceptibility, the time required for infected corn to reach physiological maturity (i.e., black layer), and most importantly, unpredictability in forecasting the weather. Most frequently, fungicides are applied at VT/R1 because leaf loss at these stages of growth contributes to a higher yield loss, but automatic fungicides at these stages are not recommended in the absence of disease. Consider a fungicide at early reproductive growth stages when rust threatens or is detected in the field; however, additional applications may be needed for season-long crop protection. Field corn that is within 2 weeks of physiological maturity (i.e., black layer) is very unlikely to benefit from a fungicide application. See MP154 for current fungicides recommendations.

Common smut is easily identifiable by its tumor-like galls containing masses of sooty black teliospores that form on actively growing corn tissue. It occurs worldwide and is considered a troublesome but not necessarily a yield-limiting disease that frequently occurs in Arkansas. In Mexico galls on ears are considered a culinary delicacy known as cuitlacoche.

Symptoms – Young galls are white and become silver-white to gray at maturity. Inside mature medium-sized galls or sori are billions of sooty black spores (teliospores). Galls are formed most frequently on developing ears and tassels, but can be found on stalks and mid-ribs (Figure 7-16). Galls may be 5 to 6 inches in diameter at maturity (Figure 7-17).

Common smut is caused by the fungus *Ustilago maydis* and only infects corn. It overwinters as teliospores in crop debris and soil. Teliospores can remain viable for several years. Infection can occur through wounds or stigma (silks). Environmental conditions that favor infection are not well understood. Galls usually develop 10 to 14 days after infection and may rupture 21 days later causing sori to dry and shrivel leaving a mass of powdery teliospores. Though conditions that favor disease are poorly understood, most agree that common smut is prevalent following rainy, humid weather. Physical damage caused by wind, hail or blowing soil may increase infection rates.

Figure 7-16. Ruptured sori of common smut on lower corn stalk.

Management – Resistant hybrids are the most practical and effective management tactic for common smut; however, no hybrid is immune. A balanced fertilization program is associated with lower common smut incidence. There are no foliar fungicides labeled for common smut control.

Fungal Stalk Rots

Fungal stalk rots are widespread and difficult to predict as the incidence and severity can vary from year to year in the same field. Stalk rots cause yield losses by increasing lodging of the crop or by cutting off the supply of water and nutrients from the roots. Premature death of the entire plant is an indicator of stalk rot. Stalk rots affect the pith of roots, crown and lower internodes (Figure 7-18). Stalk rot severity is usually increased by drought stress, hail damage, leaf diseases, high plant stand density, excessive nitrogen fertilization, low soil potassium levels, lack of crop rotation, minimum tillage and stalk feeding insects. Various discolorations of the pith, including whitish-pink to salmon, are common as is

Figure 7-17. Numerous and large galls (sori) produced by *Ustilago maydis* on an infected corn ear.

Figure 7-18. Decay of pith and root tissue caused by Fusarium stalk rot.

stalk breakage and premature decline. The exact causal organism can be difficult to identify because several fungi may invade tissue once symptoms are obvious. A few of the more common stalk rots detected in the Mid-South are detailed below.

Charcoal rot is a common stalk rot that frequently occurs with prolonged drought conditions in Arkansas. Severe yield losses may occur when hot, dry weather conditions persist during and after tasseling.

Symptoms – Early symptoms of charcoal rot include brown, water-soaked lesions on the roots, but symptoms often go unnoticed until later in the season after some lodging has occurred. The most recognizable late-season symptom is the charcoal-colored pith tissue associated with lodged plants. Late in the season, small, black microsclerotia are speckled within affected stalks, causing the stalk to appear gray-black (e.g., charcoal colored, Figure 7-19 and 7-20). Severely diseased

Figure 7-19. Gray discoloration of a split corn stalk caused by charcoal rot.

Figure 7-20. Black microsclerotia of *Macrophominia phaseolinia* speckled within a corn stalk.

stalks are weak and dry rotted causing them to lodge a few inches above the soil line before harvest.

Charcoal rot is caused by a fungus, *Macrophominia phaseolinia*, which has a wide host range that includes many agronomic crops (e.g., soybeans and sorghum). The fungus overwinters in the soil as microsclerotia (0.05 to 0.22 mm), which may infect roots and colonize the lower stalk at any time during the growing season, but is most active when soil temperature range between 86° to 100°F. Charcoal rot is often widespread and most severe during years that are hot and dry.

Management – Charcoal rot losses can be minimized with adequate irrigation during the growing season. Excessive nitrogen rates and low potassium levels dramatically increase charcoal rot severity. Thus, timely irrigation, combined with a well-balanced fertility program, can effectively reduce charcoal rot. Resistant hybrids are not available, although planting hybrids with good stalk strength is encouraged to reduce lodging.

Anthracnose stalk rot is often observed in the field after pollination resulting in premature plant death and subsequently higher yield losses.

Symptoms – Anthracnose stalk rot is relatively easy to diagnose late in the growing season by shiny black, linear streaks or blotches that appear on the surface of the lower stalk. Stalk pith tissue is often gray to purplish-brown in color, and the stalk can be easily crushed or lodged with little pressure. Anthracnose stalk rot can be differentiated from charcoal rot by the absence of microsclerotia in the pith tissue. Severely diseased stalks are weak and may lodge before harvest.

Anthracnose of corn is caused by the fungus *Colletotrichum graminicola*. This fungus overwinters on crop residue remaining on the soil surface. In the spring, when conditions favor sporulation, spores are dispersed by wind and splashing rain onto nearby plants. Anthracnose is favored by warm temperatures, heavy dew and long periods of cloudy, wet weather.

Management – Resistant hybrids are the most economical management practice; however, corn hybrids resistant to other stalk rots may not be resistant to anthracnose stalk rot. Similarly, hybrids resistant to anthracnose leaf blight are not necessarily resistant to anthracnose stalk rot. Hybrids with good stalk strength, yield potential and resistance to both phases of anthracnose should be selected. Since anthracnose overwinters in corn residue, complete burial of residue and a one-year rotation from corn will lower inoculum. Avoid plant stress by using a balanced soil fertility program and timely irrigation. Finally, if stalk rot is prevalent, harvest should be scheduled earlier to prevent additional losses.

Gibberella stalk rot is the most common stalk rot in the Midwest and occasionally occurs on corn in Arkansas. The fungus that causes this disease is also the causal agent for Fusarium head scab of wheat.

Symptoms – The most striking symptom is the reddish discoloration that occurs inside the stalk (Figure 7-21). Late in the season the outside of the infected stalk and the anchor roots may appear red.

Figure 7-21. Reddish to pink discoloration associated with Gibberella stalk rot or Fusarium stalk rot.

Gibberella stalk rot is caused by *Gibberella zea* (anamorph = *Fusarium graminearum*). Moderate, wet summer conditions promote spore production and dispersal to nearby plants. Thus, the fungus infects stalk tissue near the leaf sheaths or brace roots.

Management – Select hybrids that are adapted to Mid-South corn production with good stalk strength. Hybrids with resistance to other stalk rots may not be resistant to Gibberella stalk rot, so incorporate hybrids with good stalk strength and utilize good agronomic and cultural practices (i.e., balanced fertilizers, proper plant populations and control stalk boring and root feeding insects). Finally, if stalk rot is prevalent, harvest should be scheduled earlier to prevent additional losses.

Fusarium stalk rot is the most common stalk rot that occurs in Arkansas.

Symptoms – Fusarium stalk rot is caused by *F. moniliforme*, a soilborne fungus that is commonly found in Arkansas. Symptoms are often difficult to distinguish between Gibberella and Fusarium stalk rot as both are often associated with reddish to pink discoloration inside the stalk (Figure 7-21). Even with a laboratory diagnostic assay, the fungal spores are similar between these two fungal agents, and without the perithecium of *G. zea*, these two diseases are often indistinguishable.

Management – See Gibberella stalk rot.

Pythium stalk rot occasionally occurs in the state in isolated areas that remain wet for an extended period of time. It often occurs prior to flowering, which does not commonly occur with other fungal stalk rots.

Symptoms – Pythium stalk rot is caused by *Pythium aphanidermatum* that infects and decays the first internode region above the soil line. The infected area may appear water soaked to tan or dark brown in color. Stalks typically twist, fall over and remain green for a few weeks until the vascular tissue is completely compromised. Extended periods of heavy rainfall and hot temperatures (90°F) that contribute to flooded conditions favor disease development. Bacterial stalk rot is often mistaken for Pythium stalk rot; however, bacterial stalk rot often exudes a foul odor. A laboratory assay is often needed to distinguish the causal agent between Pythium and bacterial stalk rot.

Management – Information on Pythium stalk rot management is limited, but any practices that reduce bacterial stalk rot would likely be beneficial to minimize losses to Pythium stalk rot.

Ear and Kernel Rots

Aspergillus ear rot is caused by weak, opportunistic fungi, *Aspergillus flavus* and *A. parasiticus*. These fungi are ubiquitous and commonly found in soils across the United States. Aspergillus ear rot is most commonly observed in hot, dry years on drought-stressed corn. Though yield loss is very low with Aspergillus ear rot, the most important issue associated with this disease is the production of aflatoxin (see aflatoxin later in this chapter).

Symptoms – Aspergillus ear rot commonly occurs at the tip in association with insect damage; however, infection can occur anywhere on the ear. Yellowish to light green spores in contrast to yellow corn kernels can be seen with the unaided eye at infection sites (Figure 7-22).

Figure 7-22. Yellowish green spores of *Aspergillus flavus* colonizing the corn kernels near the ear tip.

Aspergillus spp. overwinters as sclerotia in soil and mycelium or spores in crop residue. In the summer, these fungi are active and sporulate during hot, dry weather conditions. Spores are spread by wind and insects to nearby plants. Kernels may be infected by *Aspergillus* growing on silk tissue or through wounds caused by insect damage. Drought or severe water stress and high temperatures between tasseling and grain fill predispose corn kernels to Aspergillus ear rot.

Management – Some cultural practices that reduce plant stress or minimize fungal infection can be beneficial to reduce ear rots, these include; early planting, planting adapted hybrids, adequate watering, selecting hybrids with closed husk traits and applying recommended rates of nitrogen fertilizer. Given that aflatoxin is of a greater concern, see the aflatoxin section for management options to control aflatoxin contamination.

Diplodia ear rot is most common on susceptible hybrids planted in fields with minimum tillage and continuous corn production. Although this disease causes little yield loss on adapted hybrids, it is typically found somewhere each year in Arkansas.

Symptoms – Infected ear husks appear bleached or straw color on corn during grain fill.

Husks are often "glued" by the fungus to the infected kernels, which are covered in white to gray mycelium. White mycelium often surrounds infected kernels, which are commonly located on the lower portion (½ to ⅓) of the ear (Figure 7-23). The infected ear is lighter by weight than a healthy ear, and pycnidia (coarse-ground black pepper spots) develop on glumes and cob pith tissue later in the season (Figure 7-24).

Figure 7-23. Diplodia ear rot (left) and healthy ear (right) on corn at early dent stage of growth.

Figure 7-24. Pycnidia, black specks, of *Stenocarpella maydis* on corn glumes.

Diplodia ear rot is caused by the fungus *Stenocarpella maydis*, which overwinters on corn stalks and sporulates during wet weather conditions in late spring or early summer. Spores are dispersed by splashing rain and wind onto nearby plant silks, which grow down silk tissue into the base of the ear. Alternately, infection can occur between ear shoot and stalk or sheath of ear leaf. Corn ears are most susceptible for 3 weeks after silking during wet weather conditions.

Management – Some hybrids are more susceptible than others, but the key factor in infection is rainfall during the R1 growth stage. Tillage practices that hasten the decomposition of residue reduce the inoculum for the subsequent corn crop.

Fusarium ear rot is caused by several species of *Fusarium*, which are common soilborne fungi in Arkansas. Though the impact of Fusarium ear rot on yield is minimal, corn producers should be aware of the risk of fumonisin contamination (see mycotoxin later in chapter).

Symptoms – Symptoms can vary among hybrids, but generally diseased kernels and fungal growth are most noted near the ear tip where infection is associated with insect damage. Diseased kernels are often isolated or occur in patchy clusters of several kernels on the ear. Fungal growth may be visible within these diseased kernels, which is often white to dark pink in color. Infected kernels may exhibit white streaks often called the "star burst" symptom. This symptom occurs as a result of the fungal hyphae growing under the pericarp. Although pink fungal growth and "star burst" symptoms indicate Fusarium ear rot, this is not a true indicator of fumonisin contamination, for which a laboratory analysis is needed to confirm.

These soilborne fungi produce spores that can become windblown and infect the silks; as the silks die the fungus colonizes the kernels. Alternately, the fungus can infect seedlings, grow systemically and colonialize developing kernels during kernel formation without any symptoms until later, advanced stages of disease development.

Management – There are no foliar fungicides labeled for Fusarium ear rot control. Some hybrids are less susceptible than others, so planting the least susceptible hybrid will reduce the risk of Fusarium ear rot and fumonisin contamination. Additionally, selecting hybrids with *Bt* traits that control earworms will usually result in less Fusarium ear rot.

Trichoderma ear rot occasionally occurs in the state, with a few reports of it each year.

Symptoms – Pulling back the husk is the only way this or other ear rots will likely be detected (Figure 7-25). A dark green to bluish-green fungal growth develops between kernels (Figure 7-26). The green fungal spores often cover more than half of the ear. Trichoderma ear rot could be confused with Aspergillus ear rot; however, *Aspergillus* spp. spores are much lighter in color (lime green), whereas *Trichoderma* sp. ear rot is much darker in color (forest green).

Trichoderma ear rot is caused by the fungus *Trichoderma virde*, which can be found in almost any environment across the United States. Thus, this ubiquitous, opportunistic, primarily saprophytic fungus will reproduce on any available energy source, including kernels injured by insects. Insects may play a significant role in Trichoderma ear rot infection; however, little is known about the biology of this ear rot.

Management – There are no management recommendations as this is a minor disease that does not produce any harmful mycotoxins.

Figure 7-25. Trichoderma ear rot of corn.

Figure 7-26. Dark green spores of *Trichoderma* between corn kernels.

Viral Diseases

Several virus diseases attack corn. Maize dwarf mosaic virus (MDMV) and maize chlorotic dwarf virus (MCDV) have been observed in Arkansas. Symptoms caused by infection by both viruses together are more severe than for either virus alone.

Symptoms – MDMV symptoms are highly variable but usually first appear at the base of the youngest leaves as an irregular, light and dark green mottle or mosaic which may develop into narrow streaks along veins. These can appear as dark green "islands" on a yellowish background. Leaves may become entirely yellowish-green as infected plants mature. Plants with these symptoms are sometimes stunted with excessive tillering, multiple ear shoots and poor seed set. The virus is vectored by several species of aphids, and early infection may predispose maize to root and stalk rots and premature death. Aphids usually acquire the virus from Johnsongrass in early spring and transmit it to nearby corn plants. The symptoms of MCDV include yellow to white narrow stripes on young, infected corn leaves. Infected plants are stunted to various degrees and leaves may turn partially or completely yellow and/or red, depending on the severity of the disease (Figure 7-27). Unlike MDMV, MCDV is transmitted by leafhoppers which also may acquire the virus from infected Johnsongrass.

Figure 7-27. Corn hybrid with southern corn virus complex. *Photo by Rick Cartwright*

Figure 7-28. Stunted and yellow corn caused by a high population density of stubby root nematode.

Figure 7-29. Root damage caused by stubby root nematode.

Management – Plant resistant hybrids and use good weed management practices, especially for Johnsongrass and other grassy weeds. Plant as early as possible to avoid later buildup of insects and foliar diseases. Rotate with cotton, soybeans or other non-grass crops.

Nematodes

Though more than 40 species of nematodes have been reported on corn, there is little information on the damage caused by corn nematodes in Arkansas. Some of the most common corn nematodes include root-knot, lesion, lance, spiral, stunt, dagger, sting and stubby root, which have been detected on corn in the state but not always at a damaging population threshold.

Symptoms – Symptoms vary with nematode species, population density, soil type and soil moisture. Foliar symptoms consist of stunting, chlorosis and wilting (Figure 7-28). Root symptoms include necrotic lesions, abnormal root growth and stubby roots (Figure 7-29). In contrast with our dicotyledonous row crops like cotton and soybeans, root-knot nematodes seldom cause severe galling on infected corn roots.

Management – Cultural practices that include crop rotation with a non-host or less susceptible host and prevention of soil compaction, which restricts downward root growth, are often good nematode management practices. Many corn hybrids are excellent hosts for Southern root-knot nematode (RKN), *Meloidogyne incognita*, and should not be used as a non-host rotation crop when attempting to manage RKN population densities in other crops such as cotton or soybeans.

Alternately, the reniform nematode, *Rotylenchulus reniformis*, and soybean cyst nematode, *Heterodera glycines*, do not appear to attack corn. Therefore, using corn in rotation with either soybeans or cotton where these nematodes are present will lower nematode populations. A few fumigant and granular non-fumigant nematicides are available for managing nematodes in corn, although as a general rule, they should only be considered when nematode pressure is severe. Under more moderate levels of nematode pressure, seed-applied nematicides are recommended. See MP154 for current recommendations for nematicide use on corn in Arkansas.

Note – A nematode problem is rarely detected based on foliar symptoms; therefore, if nematodes are suspected, a soil sample should be collected in the fall, shortly after harvest, and sent through the local county agent to the Cooperative Extension Service Nematode Assay Laboratory for assessment. There is a small fee for this service, but the correct diagnosis can greatly help plan future rotations.

Mycotoxins

The single most serious disease threat to Arkansas corn production is **aflatoxin** – a chemical contaminant of grain produced by certain *Aspergillus* fungi. *Aspergillus flavus* and *A. parasiticus* are weak and opportunistic plant pathogens that cause Aspergillus ear rot. These fungi are ubiquitous and commonly found in soils across Arkansas. Though Aspergillus ear rot commonly occurs at the tip, infection can occur anywhere on the ear. Yellowish to green spores can be seen with the unaided eye at infection points (Figure 7-22); however, a test kit or analytical lab assay is necessary to quantify the level of aflatoxin contamination. Aflatoxin can be produced by these fungi in the field or during storage. Predisposing factors that contribute to field contamination include drought conditions from tasseling to grain-fill, high temperatures at flowering, insect damage, nutrient (nitrogen) stress, and late planting. The optimum conditions for aflatoxin production by the fungus is at temperatures between 77° to 95°F and when kernel moisture is between 20% to 16%, thus a delayed harvest or rain during field drying may contribute to higher levels of aflatoxin. Similarly, contamination in storage is commonly associated with improper drying and storage conditions. In these situations the kernel moisture level increases and dormant fungi begin to grow and produce aflatoxin. Thus, timely harvest and proper storage conditions are key considerations to minimize aflatoxin contamination.

Aflatoxin levels are regulated by the Food and Drug Administration (FDA) beginning at 20 ppb (parts per billion) for use in food and feed, making corn grain that exceeds 20 ppb very difficult or impossible to sell or use in current marketing systems. Grain contained with greater than 20 ppb aflatoxin cannot be sold for interstate commerce. Grain that has levels that are greater than 20 ppb may be cleaned by screening out the smaller (more contaminated) kernels using a gravity table. This process can be expensive, however, and does not ensure removal all contaminated particles. Based on FDA guidelines (www.fda.gov) some contaminated grain may be used for animal feed depending on the level of contamination and the animal species that is being fed (Table 7-1). Thus, livestock producers may be willing to purchase corn at a reduced price depending on the level of contamination.

Table 7-1. Action level thresholds for using contaminated corn as feed for animals (FDA).

Animal	Maximum Acceptable Level of Aflatoxin (ppb)
Dairy cattle	20
Mature breeding beef cattle, swine and poultry	100
Finishing swine	200
Finishing beef	300

In the field, aflatoxin contamination is not uniformly distributed, and there are often hot spots within the field that have higher levels of contamination. Within these hot spots, contamination is not uniform as some ears may have no detectable level of aflatoxin while others may be extremely high. Similarly, kernels of a contaminated ear may differ in their level of aflatoxin and may range from 0 to 400,000 ppb. Thus, one kernel at 400,000 ppb can cause a 10-pound subsample to have an overall concentration of 25 ppb aflatoxin. This variability in the distribution of aflatoxin contamination within the field accounts for the difficultly in determining the aflatoxin contamination in a load of grain. Therefore, it is important to correctly sample for aflatoxin testing. It is important to collect several small samples periodically from a moving stream of grain (i.e., when unloading grain with an agar), which are combined to obtain a composite sample of at least 10 pounds of corn. If the corn is already on the truck or in the bin, sample with a probe from different locations to collect a 1-pound sample for each ton of grain that is present. Samples should be dried immediately (12%-14% moisture) to prevent aflatoxin development during shipping or storage. Dried samples should be shipped in cloth or paper bags for laboratory analysis.

A test kit or analytical laboratory test is required to determine the level of aflatoxin contamination in a sample. An ultraviolet light (blacklight test) can indicate the presence of the fungus, *Aspergillus* spp., in the kernel, but this test does NOT detect the toxin. Thus, a blacklight test is not an acceptable method to determine aflatoxin contamination. Commercial test kits (e.g., ELISA or immunoassay) are available for on-site testing of aflatoxin.

Note – The entire 10-pound sample should be ground prior to removing a subsample for the test kit.

To prevent aflatoxin contamination during the cropping season, producers have several agronomic and cultural practice options and biological control tactics. Good agronomic practices include maintaining proper irrigation from tasseling through grain fill, maintaining optimum fertility for corn production and always selecting corn hybrids that are adapted to the Mid-South. Cultural practices consist of planting early (before mid-April) and utilizing *Bt* hybrids to manage insect damage. Also, hybrids with a closed shuck morphology which completely covers the corn ear throughout the season may decrease infection by *Aspergillus* spp. and lower aflatoxin contamination. Although fungicides are not effective at suppressing Aspergillus ear rot, a biological product that contains an atoxigenic strain (non-aflatoxin producing strain) of *A. flavus* (Afla-Guard) has been shown to be effective. This biological control product is applied to the field on sterile barley seed at V10 to VT growth stage. Within a few days the fungus sporulates and competes with the natural population of aflatoxin-producing (toxigenic) *A. flavus*. As result of using this biological control practice, while green spores can be found in ears of corn in treated fields, a test kit or laboratory assay should be conducted to determine the aflatoxin level. Although Afla-Guard has been shown to reduce aflatoxin contamination by 60% to 75%, it will not reduce the aflatoxin level to an acceptable level in a high-risk field. For example, if the aflatoxin level in a high-risk field (2,000 ppb) is reduced by 75%, it still exceeds the minimum threshold at 500 ppb. Therefore, this biological management tactic is probably best suited for fields with a history of relatively low levels of aflatoxin and should be used in conjunction with other appropriate cultural and management practices that lower contamination levels.

Care should be taken at harvest to avoid undue grain contamination. Harvest the best corn first and avoid areas in the field that were stressed (areas outside the pivot or where irrigation was limited) as stressed plants potentially have aflatoxin contamination. It is a good idea to scout stressed areas for Aspergillus ear rot by peeling back the husks of 10 ears to inspect for olive-green mold. Keep in mind that Afla-Guard-treated fields will have a higher proportion of Aspergillus ear rot, but this is part of the biological control process. In non-Afla-Guard-treated fields if greater than 10% of ears inspected show signs of Aspergillus ear rot, plan on harvesting that field early. Set combines to harvest clean, whole kernels as aflatoxin is most commonly found in light, damaged kernels. Harvest corn above 18% moisture, then dry the grain to below 15% moisture within 24 to 48 hours for long-term storage of corn.

To prevent aflatoxin levels from increasing in storage, clean bins and grain-handling equipment thoroughly. Grain that collects in storage from the previous season is often a source of contamination. Clean corn should be stored at or below 15% moisture for long-term storage. Visibly moldy corn is not suitable for long-term storage. If kernel moisture levels increase, dormant fungi can begin to grow and produce aflatoxin. Although the optimum temperature range for aflatoxin production is 77° to 95°F, production can occur across a wider temperature range (52° to 104°F) when other conditions are favorable. Monitor storage bins at least every 2 weeks for changes in moisture that might have exceeded the critical level (18%) for fungal growth.

Fumonisins are mycotoxins produced by several species of *Fusarium*. Though the FDA has not established guidelines for human consumption for these mycotoxins, the maximum acceptable levels of fumonisin are 5, 10 and 50 ppm for horses, swine and cattle, respectively. The optimum conditions for fumonisin production are not known, but are suspected to be associated with early-season drought stress, similar to aflatoxin contamination. Other mycotoxins produced by *Fusarium* spp. include trichothecenes (deoxylnivalenol or vomitoxin) and zearalenone. Vomitoxin can be managed in storage by maintaining a moisture level of 15% or lower. In the field, use good cultural and crop management practices as described in the aflatoxin section to minimize Fusarium-related mycotoxins contamination of corn.