



Ear Rots

Ear rots are some of the most important corn diseases throughout the United States and Canada. Ear rots decrease yield and can greatly reduce grain quality (Figure 1).

It is critical to identify ear rots in the field because many of the fungi responsible for ear rots produce toxic chemicals (known as mycotoxins), which can harm livestock and humans. Grain that has been contaminated with mycotoxins can be difficult to market and may be docked in price.

Therefore, it is important that farmers and other agricultural personnel are able to diagnose corn ear rots and manage affected grain according to the specific ear rot present. This publication:

1. Describes how to identify the most common corn ear rots observed in the United States and Canada
2. Discusses the mycotoxins associated with each ear rot
3. Describes diseases and disorders easily confused with corn ear rots
4. Briefly addresses how to manage ear rots and affected grain



Figure 1. Corn ears infected with a fungus that causes an ear rot disease.

Aspergillus Ear Rot (disease)

Aflatoxin (mycotoxin)

Aspergillus ear rot is one of the most important diseases of corn. It is caused primarily by the fungus *Aspergillus flavus*, but a few other *Aspergillus* species may be involved. Typically, this disease is more common in the southern United States than in other areas.

Aspergillus species produce a mycotoxin called aflatoxin. Aflatoxin affects grain quality and marketability and is primarily a threat to livestock health. Aflatoxin is extremely carcinogenic and most countries (including the United States and Canada) have regulations in place to prevent aflatoxin from entering the human food and livestock feed supply.

The *Aspergillus* fungus survives in soil or crop residue and infects ears during late silking (Figure 2). Hot, dry conditions favor infection. Stressed plants (from nutrient deficiencies, drought, or feeding damage from ear-invading insects) are often more susceptible to this disease.

The fungus produces aflatoxin, which will accumulate as the fungus spreads in subsequent hot and dry weather. The fungus can infect the ear and produce more aflatoxin after physiological maturity, particularly during periods when rainfall delays harvest.

It's important to note that kernels with no visible injury or mold may still contain aflatoxin.

Signs and Symptoms

Aspergillus ear rot appears as an olive-green mold on the kernels (Figure 3). The fungal spores appear powdery and may disperse like dust when you pull back the husk. These signs are most commonly observed at the tip of the ear, but can be scattered throughout the ear and all the way to the base of the ear (Figure 4).

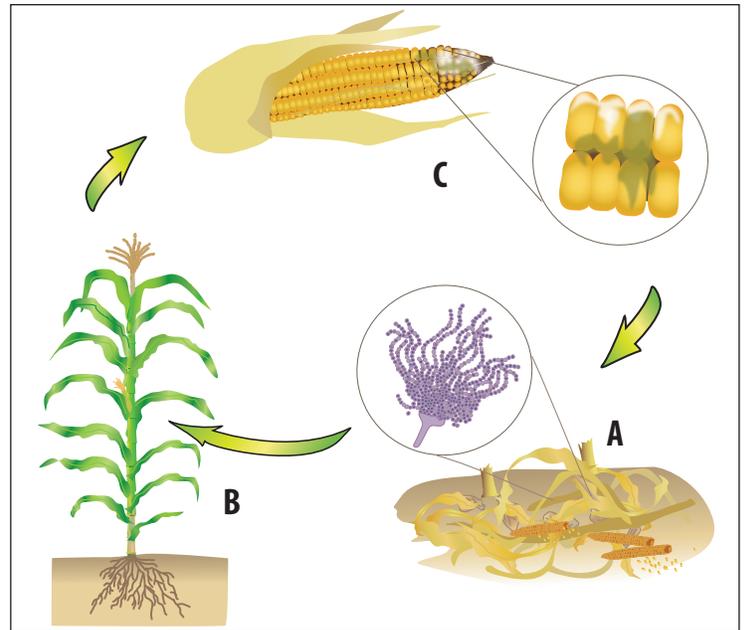


Figure 2. The *Aspergillus* ear rot life cycle.

- A.** Inoculum of *A. flavus* survives in corn residue and soil.
- B.** Insects and wind spread conidia to the ears, infecting through silks and insect wounds.
- C.** Olive-green powdery mold forms on kernels.



Figure 3. The tip of this corn cob shows signs of *Aspergillus* ear rot, which is caused by the fungus *Aspergillus flavus*.



Figure 4. The fungus that causes *Aspergillus* ear rot produces olive-green spores that are scattered throughout the ear.

Fusarium Ear Rot (disease)

*Fumonisin*s (mycotoxins)

Fusarium verticillioides is the primary fungus that causes Fusarium ear rot. The fungus survives in crop residue, and moves readily by spores on the wind (Figure 5). The fungus can infect seedlings and developing kernels, and it can grow for a time in the stalk and ear without producing symptoms or signs.

Plants can develop Fusarium ear rot under a wide range of environmental conditions. The most severe disease outbreaks occur in warm regions and in fields with extensive insect, hail, or other damage to the ears.

While Fusarium ear rot often has only a minimal effect on yield, farmers should be concerned about the risk of fumonisin contamination. Fumonisin are a group of mycotoxins that affect both human and livestock health.

Concentrations of these mycotoxins in affected fields often increase when wet, warm weather conditions persist just before harvest. Visible signs and symptoms of Fusarium ear rot can indicate fumonisin contamination, but the fumonisin concentration in the grain can be very high even when the disease does not appear to be severe.

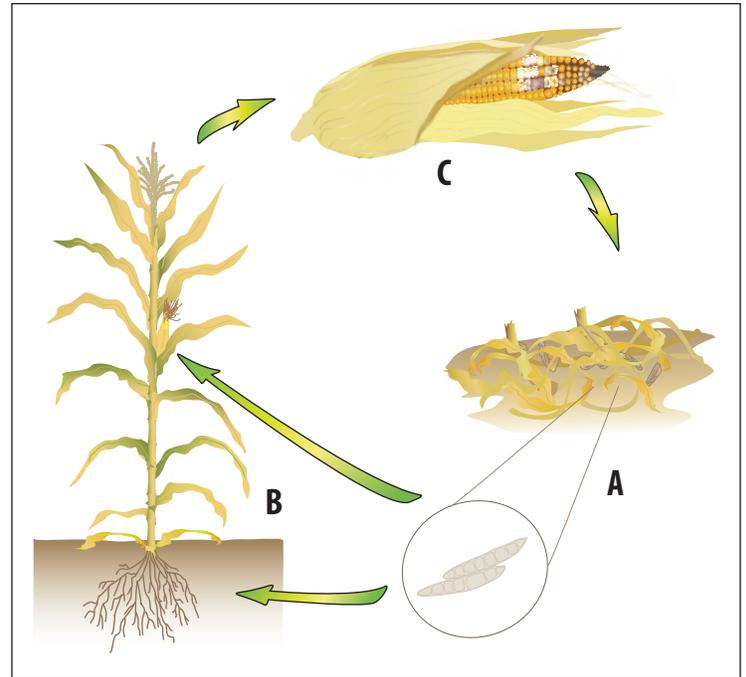


Figure 5. The *Fusarium* ear rot life cycle.

- A.** Inoculum of *F. verticillioides* survives in corn residue.
- B.** Airborne conidia infect ears via silks or insect injury; soilborne conidia infect plant roots.
- C.** White to purple, cottony mold can appear anywhere on the ear. Affected kernels are scattered and are discolored or have white streaks.



Figure 6. Ears with Fusarium ear rot have white to purple mold visible on kernels.

Signs and Symptoms

The signs and symptoms of Fusarium ear rot vary from other ear rots. Diseased kernels are scattered or in patches on the ear, especially on kernels damaged by European corn borer, earworm, or bird feeding. Fusarium-affected kernels appear purple, tan, or brown (Figure 6). When fungal growth is visible on the ear, infected kernels will appear white to pink or salmon. In some cases, kernels have white streaks (called a “starburst” symptom), which is caused by the pathogen growing under the kernel pericarp (seed coat) (Figure 7).



Figure 7. The starburst symptom on kernels is often seen on ears affected by Fusarium ear rot.

Gibberella Ear Rot (disease)

Deoxynivalenol and Zearalenone (mycotoxins)

Gibberella zeae (*Fusarium graminearum*) is the fungus that causes Gibberella ear rot. This fungus produces two different mycotoxins: deoxynivalenol (DON, sometimes called vomitoxin) and zearalenone. These mycotoxins can affect livestock, especially swine. Gibberella ear rot is most prevalent in the northern United States and Canada and is rare in warmer regions of the southern United States.

The fungus overwinters on corn and small grain residue and can infect soybean roots (Figure 8). Spores produced on the residue lead to infection during silking (Figure 9). The prevalence of Gibberella ear rot tends to increase when cool, wet weather occurs during early silking. Extended periods of rain in the fall that delay harvest increase disease severity.

Gibberella ear rot will be most severe in continuous corn fields or in areas where there is wheat affected by Fusarium head blight (scab), which is caused by the same pathogen.



Figure 8. The fungus that causes Gibberella ear rot (*Gibberella zeae*) can survive on corn stubble from one season to the next.

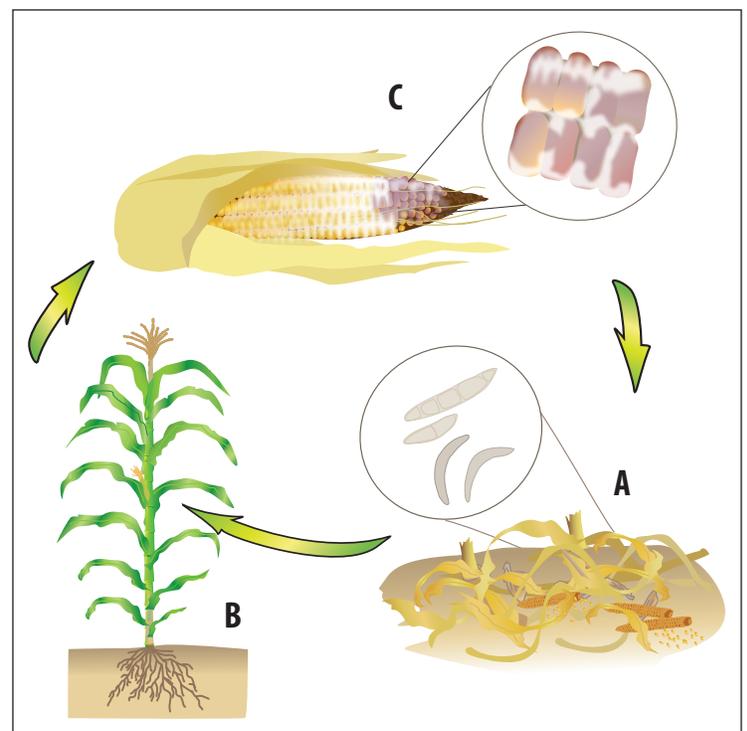


Figure 9. The Gibberella ear rot life cycle.

- A.** Inoculum of *G. zeae* survives in infected corn and wheat residue.
- B.** Splashing water and spores ejecting from specialized fungal structures spread inoculum to the ear where they infect through silks or the base of the ear.
- C.** Red or pink mold forms, typically beginning at the ear tip.

Signs and Symptoms

Gibberella ear rot produces a pinkish mold that often begins at the ear tip. On severely affected ears, the husks and silks may adhere tightly to the ear because of mold growth — such ears are called “mummified ears” (Figure 10).



Figure 10. Corn ears with Gibberella ear rot.

Except in highly susceptible hybrids or under severe conditions, the disease usually affects only part of the ears. It is relatively easy to identify Gibberella ear rot in the field on intact ears, but it is much more difficult to identify after the grain has been shelled. The concentration of the mycotoxins (DON or zearalenone) can be high even when the disease does not appear to be severe.

Diplodia Ear Rot

No Mycotoxins in North America

Diplodia ear rot is caused by the fungi *Stenocarpella maydis* and *S. macrospora* and has become a common (and troublesome) disease on corn. These fungi produce mycotoxins in South America and Africa, but no mycotoxins have been associated with Diplodia ear rot in the United States and Canada.

Pycnidia (the small, black, spore-producing structures of the fungus) overwinter on corn residue and are the source of infection for the subsequent corn crop

(Figure 11). Pycnidia appear as black specks that may be scattered on the husks, cobs, and sides of kernels.

Dry weather before silking, immediately followed by wet conditions, favor Diplodia ear rot. Fields under conservation tillage also favor Diplodia ear rot, as do fields of continuous corn. Hybrid susceptibility also contributes to disease development. Earworm damage at the ear shank is often associated with the disease. Delayed harvest and wet weather before harvest can allow fungal growth to continue, further reducing grain quality and yield.

Signs and Symptoms

On infected ears, the ear leaf generally dies prematurely when kernels are at the milk or dough stages. The Diplodia ear rot fungi produce a dense white to gray mold that appears on and between the kernels at the base of the ear and progresses toward the tip (Figure 12). Rarely, the white mold will occur only at the tip or middle part of the ear.

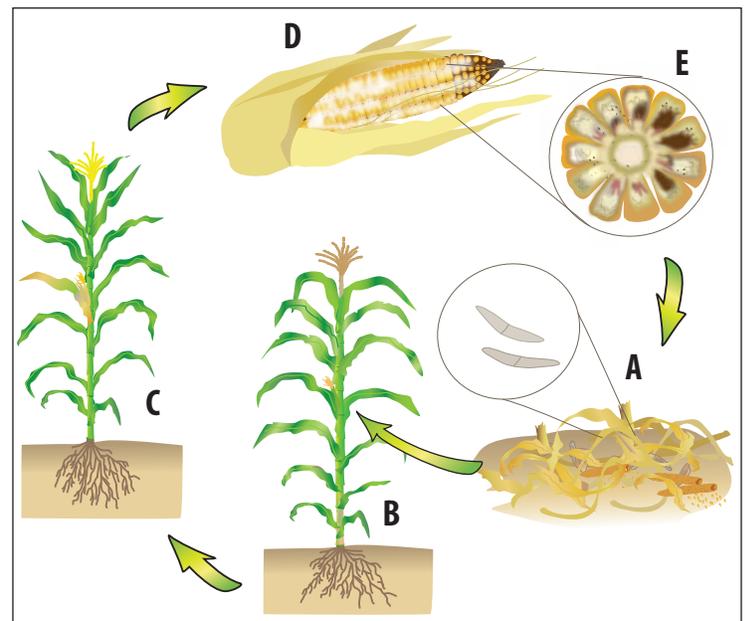


Figure 11. The Diplodia ear rot life cycle.

- A.** Inoculum of *S. maydis* and *S. macrospora* survive in infected corn residue on the soil surface.
- B.** Splashing water spreads conidia to the ear, infecting it through silks or ear shank.
- C.** Husks and ear leaves can die prematurely.
- D.** Dense white mold begins at the ear’s base, and becomes grayish-brown, eventually rotting the entire ear.
- E.** Small, black pycnidia can form on kernels later in the season



Figure 12. White mold growth on corn, indicative of Diplodia ear rot.

Infected ears weigh noticeably less than healthy ears. Occasionally, the white mold will not be prevalent, and kernels will have a brown discoloration. This appearance is called “hidden Diplodia,” and you can observe the symptoms only by breaking the ear in half and observing the fungal structures (pycnidia) in the cob (Figure 13). Often, the entire husk of affected ears will have a bleached appearance.



Figure 13. A cross-section of a corn cob with small, black pycnidia produced by the fungus that causes Diplodia ear rot.

Dangers to Livestock

Mycotoxins can severely threaten the livestock that consume them. Different mycotoxins affect livestock differently, which means it is very important to correctly identify the responsible ear rot and its associated mycotoxin (Figure 14).



Figure 14. Moldy corn has the potential to contain dangerous mycotoxins.

The U.S. Food and Drug Administration (FDA) and Health Canada have set action levels or advisory levels on several mycotoxins.

If a mycotoxin has an **action level** it means there are legal restrictions on the grain when mycotoxin concentrations reach that level.

If a mycotoxin has an **advisory level** it means there are strong cautions regarding the grain’s use when mycotoxin concentrations reach that level.

Information about specific levels for mycotoxins are available from CornMycotoxins.com.

Aflatoxin

Aflatoxin (associated with Aspergillus ear rot) is a liver toxin and potent carcinogen. When livestock consume aflatoxin they can experience a variety of health issues including suppressed immune systems, reduced weight gain, cancer, and death.

The toxicity of aflatoxin varies among animal species, but young animals are most sensitive to the toxin. Furthermore, when lactating animals consume contaminated grain, the aflatoxin is present in the animal’s milk (Figure 15).

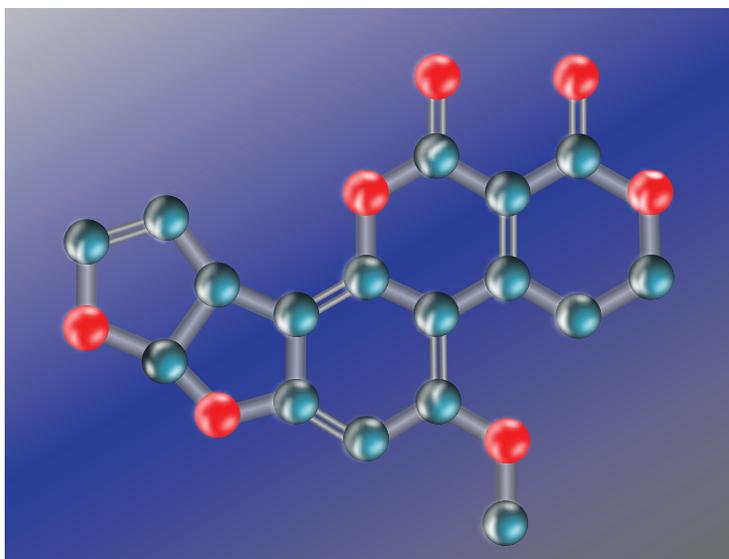


Figure 15. This illustration shows the structure of the aflatoxin compound. Lactating animals that consume feed contaminated with aflatoxin can pass the toxin to their young through their milk.

Fumonisin

Fumonisin (associated with *Fusarium* ear rot) can cause fumonisin poisoning, which is associated with a number of toxic effects, including equine leukoencephalomalacia (ELEM, also called blind staggers) and porcine pulmonary edema.

Equine and swine are the most sensitive to fumonisin.

Deoxynivalenol and Zearalenone

Deoxynivalenol and zearalenone (associated with *Gibberella* ear rot) can be dangerous to livestock.

Deoxynivalenol (also called DON and vomitoxin), can cause swine and other animals to vomit and refuse to eat.

Zearalenone has estrogenic properties, which means it can cause infertility, abortion, and other breeding problems. Swine are the most sensitive livestock to zearalenone. A feed ration with as little as 1 to 5 parts per million (ppm) of zearalenone may produce an estrogenic effect in swine.

Diplodia Ear Rot

There are no reports in the United States or Canada that the fungi that cause *Diplodia* ear rot have produced mycotoxins. If you observe adverse effects on livestock after feeding them *Diplodia*-affected grain, promptly contact your local extension service.

Scouting for Ear Rots

To manage and minimize the effects of these ear rot diseases, it is critical to assess fields before harvest. You should assess fields each year, because these pre-harvest assessments can alert you to potential problems and provide time for livestock producers to segregate, obtain alternative grain, or hold onto stored corn from the previous year.

Scouting practices are similar for all corn ear rots. Begin scouting fields at late dent stage to determine the presence and severity of ear rots. When scouting, randomly select plants and pull back the husk to examine the entire ear (Figure 16). A quick method is to select 100 plants across the field (20 ears each from five different areas). For each ear, be sure to peel back the husks and examine the entire ear.

If a field contains a significant level of ear mold, collect a representative sample at harvest and have it tested for mycotoxins before storing the grain or feeding it to livestock. A lab test is often the only reliable way to definitively diagnose an ear rot or mycotoxin.

More information about grain sampling and mycotoxin testing is available in *Corn Disease Management: Grain Sampling and Mycotoxin Testing* (CPN-2003), available from the Crop Protection Network, CropProtectionNetwork.org.

If you suspect a field is contaminated with a mycotoxin, contact your crop insurance agent. If you need to file a claim, your agent may require an adjuster to visit the field *before* harvest.



Figure 16. When scouting for corn ear rots, pull back the husk to examine the entire ear.

Managing Ear Rots

Corn infected by ear rots will often result in significant discounts on the grain. Kernels with an ear rot disease can be lighter than healthy kernels (which will lower the test weight of a sample), and elevators can dock grain that contains mold. Mycotoxin contamination can lead to further discounts.

General management practices apply to most ear rots.

Choose what you plant carefully. In fields with a history of ear rots, choose a corn hybrid that is less susceptible to the specific ear rot. You may also want to select hybrids with insect resistance traits, which can help reduce the occurrence of ear rots.

Promote conditions that favor healthy plant growth and reduce plant stresses. Make sure plants receive adequate water and nutrients, and minimize insect-related and other damage.

Don't rely on fungicides. It is important to note that the foliar fungicides currently available are *not* generally recommended to manage ear rots and mycotoxins. There may be some fungicides available for *Gibberella* and *Fusarium* ear rots in the United States, but these products currently require a FIFRA Section 2(ee). Check with your state extension service (or in Canada, with the Pest Management Regulatory Agency) before using fungicides to control corn ear rots.

In areas with high levels of *Aspergillus* ear rot and a history of frequent aflatoxin contamination, consider using an atoxigenic fungal strain to reduce aflatoxin accumulation. More information about using atoxigenic strains to manage aflatoxin can be found in *Corn Disease Management: Using Atoxigenics to Manage Aflatoxin* (CPN-2005), available from the Crop Protection Network, CropProtectionNetwork.org.

Harvest infected fields early and segregate the grain. Leaving diseased grain in the field allows the ear rot fungi to keep growing, which will increase the risk of moldy grain and mycotoxin contamination. Most ear rot fungi continue to grow (and, if applicable, produce mycotoxins) until the grain has less than 15 percent moisture. In severely infected fields, it may be worthwhile to harvest grain at a higher moisture and then dry it to less than 15 percent to minimize the further mycotoxin accumulation (Figure 17).

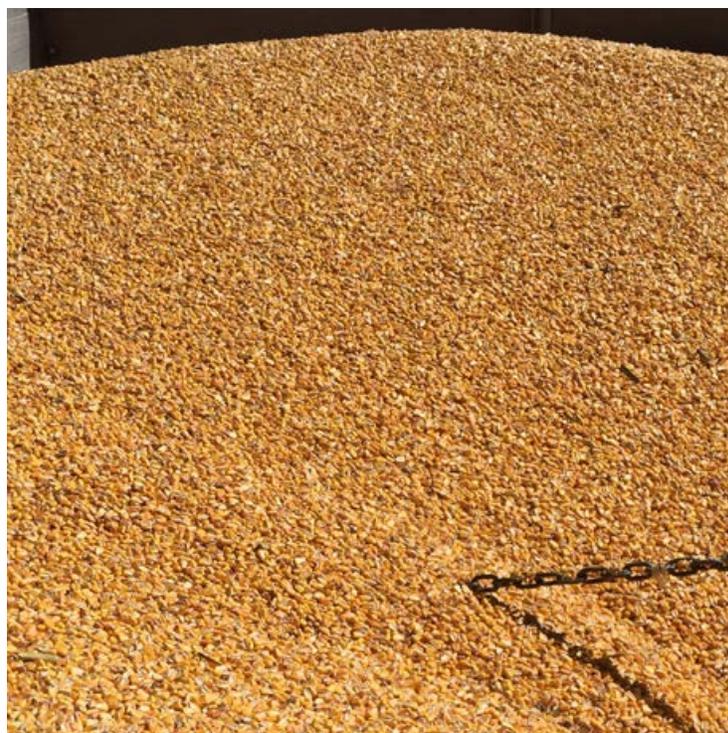


Figure 17. Dry infected grain to avoid further mycotoxin accumulation.

Never mix grain from a field affected by ear rots with grain from a field that has not been affected.

During harvest, adjust the combine to discard lightweight or damaged kernels. These kernels may contain mold and mycotoxins. Segregate poor-quality grain from good-quality grain, and clean moldy grain out of your equipment before using it on clean grain to prevent cross-contamination.

Storing Affected Grain

It is crucial to properly store corn affected by ear rots. You must quickly dry and cool grain after harvest to limit fungal growth and the further mycotoxin accumulation in storage.

The standard recommendations for long-term storage are to dry contaminated grain to less than 13 percent moisture and to cool it to 30°F (-1°C). Whenever possible, only store affected grain during the cold weather season.

More information about storing grain is available in *Corn Disease Management: Storing Mycotoxin-affected Grain* (CPN-2004), available from the Crop Protection Network, CropProtectionNetwork.org.

Diseases and Disorders with Similar Symptoms

There are several conditions that have symptoms similar to the ear rots that can produce mycotoxins. Corn is also susceptible to several other ear rots that are less harmful than the others described above. These other ear rots are usually minor in incidence and severity, but can be confused with the more important ear rots, namely *Aspergillus* ear rot.

Cladosporium Ear Rot (*Cladosporium* spp.)

Cladosporium ear rot is caused by *Cladosporium* fungal species that do not produce any known mycotoxins. Look for scattered dark, green-black kernels throughout an ear (Figure 18). The kernels can also appear slightly shriveled and may split open, revealing tufts of fungal growth. The fungus can cause kernels to develop black, irregular streaks. The dark green, fuzzy fungus can also grow on and between kernels. Wet weather near harvest favors Cladosporium ear rot. Plants with damage from frost, hail, or insects are more susceptible to infection.

How to distinguish Cladosporium ear rot from major ear rots:

None of the other major ear rots form irregular black streaks on corn. Infected kernels also tend to be more scattered across a corn ear than the other major ear rots and do not tend to form a mat of fungal growth.

Figure 18. Corn showing symptoms of Cladosporium ear rot.



Nigrospora Ear Rot (*Nigrospora oryzae*)

Nigrospora oryzae is the fungus that causes Nigrospora ear rot. It is a weak parasite that is most prevalent late in the growing season on corn that has been stressed or damaged by other diseases or environmental factors. Signs of Nigrospora ear rot include gray fungal growth on corn kernels and small, black spores (Figure 19). Corn cobs with Nigrospora ear rot can be prone to shredding during shelling.

How to distinguish Nigrospora ear rot from major ear rots:

Nigrospora ear rot can be distinguished by the small black spores the *N. oryzae* fungus produces. These spores, unlike the pycnidia of *Diplodia* ear rot, can be removed by rubbing them with your finger.

Figure 19. Corn with signs of infection by *Nigrospora oryzae*, the fungus that causes Nigrospora ear rot. The inside of the broken cob (bottom) shows the small, black spores the fungus produces.



Penicillium Ear Rot (*Penicillium* spp.)

Several *Penicillium* species can cause Penicillium ear rot. Although Penicillium ear rot is associated with the mycotoxin ochratoxin, not all *Penicillium* species produce the mycotoxin. Signs of Penicillium ear rot include a blue-green powdery growth on and between corn kernels (Figure 20). Penicillium ear rot is typically found on ears that have been injured mechanically, or by insects or hail.

Colonized kernels can appear streaked and bleached, and if the moldy growth gets into the kernel embryo it causes blue-eye of corn. Fungal growth usually appears at the ear tip, but can also be found on the injured portions elsewhere on the cob. Wet, humid conditions after grain-fill favor infection. The fungus also may continue to spread in grains stored at greater than 17 percent moisture.

How to distinguish Penicillium ear rot from major ear rots:

Penicillium ear rot can be distinguished from the other ear rots by its blue hue. Additionally, it is the only ear rot that causes blue-eye of corn.

Figure 20. Corn with signs of Penicillium ear rot.



Trichoderma Ear Rot (*Trichoderma* spp.)

Several different species of *Trichoderma* fungi can cause Trichoderma ear rot. The disease can affect injured ears (from insect feeding, heavy storms, etc.). Some (but not all) of the fungi that cause Trichoderma ear rot can produce a mycotoxin in a group of molecules called trichothecenes.

A common sign of Trichoderma ear rot is dark, blue-green spores that grow on and between the kernels of an infected ear. Trichoderma ear rot can also cause corn kernels to germinate prematurely (called sprouting or vivipary), which is distinct to Trichoderma ear rot (Figure 21). Ears affected by Trichoderma ear rot may weigh much less than uninfected ears from the same field.

How to distinguish Trichoderma ear rot from major ear rots:

Trichoderma fungal spores tend to be brighter green than those of *Aspergillus flavus*, and they tend to grow in between the kernels, whereas the *A. flavus* fungus tends to grow from a relatively confined area. Additionally, the major ear rots do not typically cause kernels to germinate prematurely.

Figure 21. (Top). An ear with blue-green mold, indicative of the fungi that cause Trichoderma ear rot. (Bottom) Spores of the *Trichoderma* fungus growing in between the kernels on a corn ear.



Corn Smut (*Ustilago maydis*)

Ustilago maydis is the fungus that causes corn smut. When it infects corn, it causes the kernels to grow into gray, tumor-like fungal masses, called galls (Figure 22). As these masses develop, they form dark black spores inside. When the fungus dries out, the mass will open to release the spores.

How to distinguish corn smut from major ear rots:

The gray galls *U. maydis* forms are distinctive structures that none of the ear rots will form. Although ear rot fungi may mummify corn kernels or cover them with sooty spores, they will not form galls. The corn smut fungus can produce galls on any plant part (brace roots, leaves, stalks, tassels).

Figure 22. The gray, tumor-like gall on this cob was caused by *Ustilago maydis*, the fungus that causes corn smut.



Black Corn (various fungi)

Several species of saprophytic fungi can cause black corn. The fungi are weak parasites that colonize ears that are already stressed (from insect feeding, hail, lodging, etc.).

Signs of black corn infection typically include black or dark-colored fungal growth, primarily on senescing tissue (leaves, husks, etc.). The color can vary, and if conditions are favorable for fungal growth, they may infect the kernels.

How to distinguish black corn from major ear rots:

The fungi that cause black corn tend to infect senescing tissue in addition to the kernels. Infected ears tend to be black and sooty, primarily on the husk rather than on kernels and cobs (as with ear rots).

Figure 23. Black corn typically produces black or dark-colored fungal growth, primarily on senescing tissue (leaves, husks, etc.).



Table 1. A general guide to corn ear rots.

Ear Rot	Mycotoxin Produced	Conditions Favoring	Signs and Symptoms
Aspergillus	aflatoxin	Hot and dry	Olive-green spores on ear
Fusarium	fumonisin	Moderate to warm temperatures during silking, wet periods before harvest	White to purple mold scattered across ear; starburst pattern in kernels
Gibberella	deoxynivalenol (DON or vomitoxin) and zearalenone	Cool and wet	Pink to white mycelial growth
Diplodia	None currently known in U.S. and Canada	Moderate temperatures, wet during silking	White mycelial growth on ear and husk; black pycnidia in cob
Penicillium	ochratoxin (only some species)	Wet, humid conditions after grain-fill	Blue-gray fungal spores
Nigrospora	None	Damaged corn	Black spores, gray mycelia, shredding cob
Cladosporium	None	Wet weather near harvest	Dark-green to black kernels
Trichoderma	trichothecenes (only some species)	Damaged corn	Blue-green spores growing in and on kernels; may cause sprouting

Find Out More

The Crop Protection Network (CPN) is a multi-state and international collaboration of university and provincial extension specialists, and public and private professionals who provide unbiased, research-based information to farmers and agricultural personnel. Our goal is to communicate relevant information that will help professionals identify and manage field crop diseases.

Find crop disease resources at CropProtectionNetwork.org.

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