Diagnosis and Management of Ear Rot Disease

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Scouting for Ear Rots

Fungal pathogens of many ear rot diseases may not always have a significant impact on initial yield; however, their effects can be felt later at the elevator due to reduced quality caused by the fungi or the mycotoxins produced by some fungal ear rot pathogens. It is crucial to assess field for ear rots every year before harvest, as identification of specific ear rots can alert you to potential problems and guide management decisions to mitigate damage from ear rots and associated mycotoxins. Scouting for all ear rots can begin at late dent stage, R5. To evaluate a field, choose 100 ears (20 ears from 5 different places in the field) and pull back the husk so the ear is fully visible. If more than 10 percent of ears show signs of ear rot, growers should prioritize harvesting those affected fields first.

Aspergillus Ear Rot

Aspergillus ear rot (AER) is a major disease of corn that can produce aflatoxin, a carcinogenic mycotoxin. There is a diversity of species within the genus of *Aspergillus* associated with causing ear rot. Two of the most common species are *Aspergillus flavus* and *A. parasiticus*.

Symptoms: The most common symptom of Aspergillus ear rot is the presence of yellow to olive-green patches of spores on or between the kernels. While any part of the ear may be infected with the disease, symptoms are often seen at the tip of the ear that has received damage either from biotic or abiotic factors.

Favorable conditions: *Aspergillus* infection and development is favored by hot, dry temperatures (86ºF), and is most severe under drought conditions during pollination and grain fill.

Plant stress plays an important role in AER and aflatoxin production. Conditions such as hillsides, sandy soils, nutrient deficiency, and dense plant populations can result in severe infections.

Yield effect: The majority of the time, yield loss caused by AER rot is associated with drought stress. This can make it difficult to estimate the damage done solely by the disease, but the pathogen can reduce the weight of infected kernels. An indirect impact on yield is monetary loss due to price reductions or rejection at grain elevators due to aflatoxin levels that are above action threshold. It has been estimated that aflatoxin contributes $163 million loss annually for US corn growers (Wu 2006).

Insect damage with olive green spores from AER. Photo credit: C. Cooke

Management: Pre-harvest management strategies start with planting a variety that is adapted to the southern region, along with moderate or above rating for drought tolerance. Managing overall plant health by providing optimal conditions for growth such as the use of fertilizer, correct planting population, and optimum watering during silk to late-dough stage. Managing secondary plant stressors such as weeds, foliar diseases, and insects is part of disease management for AER. No fungicides are labeled for use for AER, however there is also a biological control (Afla-Guard® GR, Syngenta – Labeled for use in TN) in which a species of *A. flavus* that does not produce aflatoxin is applied in the field at growth stages V7 – R1.

Mycotoxin: The production of aflatoxin is the most detrimental aspect of AER, as it is carcinogenic. Aflatoxin levels may increase after harvest if grains aren't dried below 15% moisture and stored in at least 50ºF. The presence of aflatoxins affects grain quality and marketability. The FDA has established action thresholds for aflatoxin in human and animal food/feed set at 20 ppb (TABLE 2).

Mummified corn ear with tight husk from DER on the left, while the dehusked ear on the right shows mold growth throughout. Photo credit: A. McLaughlin

Diplodia Ear Rot

Diplodia ear rot (DER) is caused by the fungal pathogens *Stenocarpella maydis*, which is also the causal agent for Diplodia Stalk Rot, and *S. macrospora*, which is also associated with the foliar disease – Diplodia leaf streak. The occurrence of Diplodia ear rot has increased since the adoption of no-till systems.

Symptoms: DER can be observed in plants as early as R3 (Milk) stage. Infected husks are often bleached while the rest of the plant remains green. The identifying characteristic of the fungi are white mold starting at the base of the ear and as the rot progresses the whole ear becomes grayish-brown. The presence of raised black bumps (pycnidia) that develop on the moldy husk or kernels late in the season is also a distinguishing feature.

Favorable conditions: Dry weather followed by wet conditions during R1 (silking) favor the pathogens that can cause infection of the ear, and delayed harvest can make disease more severe, further reducing grain quality and yield. Birds and insect damage to the ears also predispose plants to infection.

Yield penalty: Infected kernels are lightweight and have reduced nutritional value. The friable nature of the infected ears can also result in more cobs and kernels being ground up during the combine shelling operation, resulting in higher levels of broken and foreign material. It was estimated that 167 million bushels were lost between 2012 and 2015, across USA and Canada due to DER (Mueller et al 2016).

Cross section of Diplodia Ear Rot with pycnidia. Photo credit: Rodrigo Mendoza, 2017.

Management: The most important source of inoculum of DER is the debris of diseased corn stalks from the previous crop, therefore reducing surface residue through tillage is an effective practice to control disease. However, where tillage is not suitable, growers should look for hybrids that are less susceptible and rotate to non-host crops.

Fusarium Ear Rot

Fusarium ear rot (FER) is the most common ear rot disease and is caused by several species of *Fusarium*, most commonly *Fusarium verticillioides*, *F. proliferatum* and *F. subglutinans*. *F.verticillioides* and *F. proliferatum* are associated with the production of the mycotoxin fumonisin.

Sporadic/patchy white cottony fungal growth between kernels is a sign of FER. Photo credit: A. McLaughlin

Symptoms: Fusarium ear rot can appear as a white to peachy/purple, cottony mold, affecting individual or groups of kernels that are infected sporadically throughout the ear. Infected kernels are often tan or brown or have white streaks often referred to as a starburst pattern. This symptom is caused by the pathogen growing under the kernel pericarp. The symptoms of this disease vary according to genotype, climate, and disease severity.

Favorable conditions: Fusarium ear rot occurs under a wide range of weather conditions, but it is most severe under high temperatures (above 77ºF) and wet periods before harvest. Infection can occur through the silks, but insect or hail damage can result in wounds that help facilitate the pathogen. Although infection happens during silking, the fungi can continue to spread on infected ears past R6 stages and until grain moisture is below 18%. The optimum temperature for fumonisin production is 75ºF.

Yield penalty: Diseased grains will have reduced grain quality. In severe infections, ears may be completely consumed by the fungus leaving lightweight husks cemented to the kernels by mycelia. In the United States, it was estimated that the average annual loss due to fumonisins in corn is $40 million (Wu 2006).

Symptom often referred to as a "starburst pattern" of *Fusarium* infected kernels. Photo credit: M. Cartwright.

Management: *Fusarium* species overwinter in seeds, plant debris and secondary hosts. Although seed transmission does not play a large role in ear rot development, cultural practices such as crop rotation and tillage may reduce inoculum from plant debris. In severely affected fields, aforementioned techniques might be ineffective due to airborne spores from neighboring areas. Corn varieties have different levels of susceptibility to *Fusarium* species. The management of ear-damaging caterpillar pest, such as the use of plant-incorporated Bt (Bt corn hybrids), can reduce disease infection and mitigate fumonisin.

Mycotoxins: Fumonisins are acutely toxic to animals, especially pigs and horses which cause porcine pulmonary edema and equine leukoencephalomalacia (ELEM, or blind staggers), respectively. In humans, fumonisins have been listed as potentially carcinogenic and associated with birth defects. As a result of these risks, the FDA has established advisory levels for the maximum amount that may be present in food and feed (TABLE 2).

Gibberella Ear Rot

Gibberella ear rot (GER) is a worldwide disease, caused by the pathogen *Fusarium graminearum* (Synonym *Gibberella zeae*), which also causes Gibberella stalk rot on corn and Fusarium head blight on wheat and barley. The mycotoxins Deoxynivalenol (DON) and Zearalenone are associated this pathogen.

Symptoms: GER is characterized by a pink to reddish mold that appears at the tip and grows down the ear. In early ear infection by the disease the entire ear may rot and be covered with a pinkish mycelium that causes the husk to tightly adhere to the ear. A superficial blue or black perithecia may cover the husk and ear shanks. The disease normally only affects a portion of the ear, except in highly susceptible hybrids.

Pink-Reddish mold on the tip of the ear sign of GER. Photo credit: Pioneer.

Favorable conditions: Spores infect the plant through the silk and are most susceptible to infection 2-6 days after silk emergence. GER is more severe under cool and wet conditions after silking stages. Although infection occurs during silking, disease symptoms can keep developing after R6 until grain moisture is below 18%, especially under extended periods of rain in the fall that delay dry down. Insect damage can enhance disease infection and increase its severity.

Yield penalty: Gibberella ear rot reduces grain dry matter and consequently yield and test weight, which may reduce grain grade and price. Grains with GER may not be suitable to feed and food uses due to mycotoxin contamination.

Red discoloration caused by Gibberella stalk rot. Photo credit: A. Robertson.

Management: Gibberella ear rot remains in the field on plant debris and can also increase in the winter on wheat (Fusarium head blight). Therefore, cultural practices such as crop rotation and tillage can help reduce inoculum levels. Corn hybrids differ in susceptibility, those with loose husks tend to be less susceptible. Limited fungicides are currently labeled for management of this disease. It was estimated about 251.6 million bushels were lost between 2012 and 2015, across USA and Canada due to the disease (Mueller et al. 2016).

Mycotoxins: Deoxynivalenol (DON or commonly known as vomitoxin) and Zearaleonone are important mycotoxins. Animals may refuse to consume grains with DON and regurgitate consumed food. Animals that consume DON can experience infertility, abortion, and death.

Minor/Less Common Ear Rots

Penicillium Ear Rot

Penicillium ear rot (PER) is a worldwide disease, caused by numerous species of *Penicillium*, some of which produces mycotoxins such as ochratoxins.

Symptoms: *Penicillium spp.* can cause damage in the field and in stored grain. Diseased kernels have a green, blue-green, or denim-blue, powdery mold. Infected kernels can appear bleached or streaked. If stored at high moisture, the pathogen may enter kernels and grow in the germ causing the symptom known as "blue-eye".

Favorable conditions: Inoculum overwinter in the soil and other host plants. Spores can disperse by wind and rain and infect primarily damaged ears. This disease usually doesn't require management.

Mycotoxins: Ochratoxins are toxic to swine and can cause porcine nephropathy. They are also toxic to chickens and ducks.

Denim blue mold from older/dried PER Photo Credit: Jessica Krob

Common Smut

Common smut, caused by the pathogen *Ustilago maydis*, is common in corn-growing areas, but it rarely results in major yield losses and does not produce mycotoxin. While it is not an ear rot, it is often mistaken as one.

Galls formed on the ear replacing kernels. Black teliospores can be observed developing on the abnormal growth. Photo credit: Elias Zuchelli

Symptoms: Abnormal growth (galls) may develop anytime throughout the growing season on stalks, leaves, or tassels but is most easily recognized when they develop on the ear replacing kernels with abnormal bluish- silvery tissue that is fleshy to the touch. Later within the season, black teliospores of this fungus bust out of the abnormal growth. Young, actively growing tissue are especially susceptible to this disease.

Favorable conditions: Conditions that interfere with pollination may favor infection of ears. Common smut is the most severe type of smut when young tissue is injured by hail, wind, or mechanical damage. Poor pollination and excessive nitrogen fertilization, as well as rainy, wet weather, can exacerbate this disease.

Table 1: Identification Keys for Economically Important Ear Rots:

Disease	Symptom	Environmental Conditions	Ear occurrence	Mycotoxin
Aspergillus Ear Rot	Yellow to olive-green spores	Hot, dry conditions (86ºF)	Top/tip of the ear	Aflatoxins
Diplodia Ear Rot	White mold (early) grayish brown mold (late)	Dry weather followed by wet conditions during R1 (silking)	Base of the ear	None
Fusarium Ear Rot	White to salmon/purple cottony mold	Most severe under high temperatures (above 77ºF) and variable moisture	Individual or group of kernels on ear	Fumonisins
Gibberella Ear Rot	Pink to reddish mold	Most severe under cool and wet conditions after R1	Top of the ear	Zearalenone and Deoxynivalenol

Table 2. Mycotoxins Action or Advisory Levels:

Intended Use Category	Fumonisins (ppm)	Aflatoxin (ppb)	Deoxynivalenol (ppm)
Humans	2 - 4	20	1
Milk for Humans	-	0.5	-
Horses	5	20	5
Swine	20	200	5
Beef Cattle	60	300	10
Dairy Cattle	-	20	5
Chickens	100	300	10
Other Animals	10	20	5

Table 2: Action and Advisory levels set by the US Food and Drug Administration (FDA). **Action levels** are concentrations of mycotoxin reach the level for the intended use, there are legal restrictions on the grain. **Advisory levels** are meant to to strongly caution and provide mycotoxin concentration levels for safety based on the intended use of the grain.
* Levels established according to FDA at available at <*Memo to the Manager (ngfa.org)>

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References:

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Wu, F. 2006. Mycotoxin reduction in Bt corn: Potential economic, health, and regulatory impacts. Transgenic Res. 15(3): 277–289. doi: 10.1007/s11248-005-5237-1.

Additional information on ear rots and mycotoxins: https://cropprotectionnetwork.org/publications/an-overview-of-ear-rots