First Place Student Essay

Biology and Management of Diplodia (*Stenocarpella maydis*) Ear and Stalk Rot

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DIPLODIA ear rot has a long history throughout the United States Corn Belt. This disease was considered to be the most important ear rot disease in the early 1900's (Burrill and Barrett, 1909). Reports indicate that 4.5 percent of the Illinois corn crop was destroyed by Diplodia in 1906 and 2 percent in 1907 (Burrill and Barrett, 1909). Diplodia ear rot maintained its prominence as reported in 1930 and 1959 (Koehler and Holbert, 1930; Koehler, 1959). However, this fungal pathogen almost disappeared in the 1960's and 1970's due, in large part, to the use of the moldboard plow (White and Malvick, 2001). But over time Diplodia has staged a comeback, aided by the widespread adoption of conservation tillage practices (White, 1999). In fact, over 37 percent of the total U.S. corn acres in the year 2000 were planted in some sort of conservation tillage practice and the trend was rising (Conservation Technology Information Center, 2002). In order to understand this disease better, this essay will review this pathogen's life cycle, the crop damage it causes, and management practices which can be implemented.

Biology

Diplodia is a member of the Imperfect Fungi (Agrios, 1997). Diplodia ear rot and stalk rot are caused by the fungal pathogen *Stenocarpella maydis* (Berk.) Sutton syns. = *Diplodia maydis* (Berk.) Sacc. = *Diplodia zeae* (Schwein.) Lev. (White, 1999). Corn is the only known host of Diplodia spp. in the United States (Partridge, 1997).

Diplodia takes different forms during its life cycle. In one form, the fungus survives the winter on corn debris such as stalks, cobs and kernels which are left on the soil surface. During wet weather in the spring, the fungus produces fruiting bodies called pycnidia which contain the asexual fungal spores called conidia (Agrios, 1997). Rainsplash disseminates these spores to the ear leaf, ear shank and/or the silks. The amount of inoculum in the field residue at the soil surface influences the level of crop infection. Typically, husk infection occurs at the base of the ear and the fungus develops between the ear shoot and the stalk or between the shoot and the sheath of the ear leaf (White, 1999). Diplodia can also penetrate the ear shank and grow up into the cob and in between the kernels (Vincelli, 1997). In addition, the fungus can grow down the silks and infect the ear (White, 1999). Bird and insect feeding to the ear tips also helps the pathogen gain entry into the ear (White, 1999). If fungal entry occurs at the tip of the ear, infection will begin there.

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Symptomalogy

The most common symptom of Diplodia ear rot is a thick, white mold that generally starts at the base of the ear and grows upward between and over the kernels. A severe infection can cause the entire ear to be shrunken and the infected kernels to be enveloped in mold (White, 1999). A unique characteristic of this fungus is that often late in the season, raised, fruiting bodies will develop on moldy husks or kernels (Lipps and Mills, 2002). Severely affected ears can be noticed at a distance, as the husks turn brown and dry down while the remainder of the plant is still green.

Ears are most susceptible to infection during the first three weeks of silking (White, 1999). Susceptibility of ears to infection steadily declines thereafter, although some ears can be infected as long as four weeks after mid-silk (50 percent of plants have silks) (Vincelli, 1997). Dry weather prior to silking followed by wet weather during silking seems to increase the incidence and severity of Diplodia ear rot (Woloshuk and Maier, 2000). The coordinated timing of spore release and plant silking could be responsible for this relationship (Vincelli, 1997).

According to Lipps and Mills (2002), timing of the infection is crucial to the severity of the disease symptoms. If infection occurs early, the entire ear could be diseased and moldy. Should infection occur later, after silking, only a portion of the ear may be affected. Very late infections result in only a fine web of growth on the kernels. Severe infections can cause kernels to rot. These rotted kernels may exhibit a condition called vivipary, which means they may germinate prematurely (Partridge, 1997). Seedlings grown from infected kernels usually develop seedling blight (Partridge, 1997).

Accordingly, injury follows symptoms. The amount of affected ears in a field can range from 1 to 80 percent (Vincelli, 1997). Once again, the timing of infection is related to level of injury. Vincelli (1997) reports that the fungus can occur at any reproductive stage, from blister to black layer (physiological maturity). If infection occurs at the blister stage, the fungus can prevent the ear from producing grain fit for harvest. The infection causes less damage in the later maturity stages.

Stalk Rot

Timing, as was the case for ear rot, is important for the development of Diplodia stalk rot as well. Infected stalks serve as the primary source of inoculum for the following growing season (White, 1999). This disease develops when *Stenocarpella maydis* infects corn plants through the crown, mesocotyl, or roots (White, 1999). Subdermal black pycnidia embedded in the rind tissue of the lower corn stalk is characteristic of this fungal stalk rot (White, 1999). Anderson and

White (1994) found that stalk rot ratings for Diplodia stalk rot were higher with inoculation at 2 weeks and 4 weeks after anthesis than at anthesis. Diplodia stalk rot can weaken the lower parts of the stalk where infection is likely to occur. This makes the stalks very susceptible to lodging in a high wind or other stress. While stalk boring insects can compound this problem, many days of cloudy weather, which limits photosynthesis, can as well (Hellmer, 2000). Fields stressed by drought, disease or low fertility could additionally compromise stalk strength (Hellmer, 2000).

Impact on Corn Quality

One problem associated with fungal pathogens of grain is the production of mycotoxins. Fortunately, there are no known mycotoxins associated with Diplodia ear rot in the United States (Hollis and White, 2000). However, Diplodia can be followed by Fusarium, which can produce the fumonisin toxin (Hollis and White, 2000). This toxin can be deadly to horses and problematic to swine, so producers are advised to use available kits to test affected grain for fumonisin before feeding (Hollis and White, 2000). Incidentally, while Diplodia ear rot produces no mycotoxins in the U.S., it does seem to be a problem in southern Africa. Diplodia is the most common pathogen of corn there causing reductions in yield and grain quality as well as a condition called diplodiosis in cattle and sheep (Flett and McLaren, 1994; Kellerman et al., 1985; Kellerman et al., 1991). Diplodiosis is a nervous condition characterized by ataxia, paresis and paralysis (Kellerman et al., 1985; Kellerman et al., 1988). Research indicates diplodiosis also affects poultry (Rabie et al., 1987). Admittedly, outbreaks of this condition have not occurred outside of southern Africa (Kellerman et al., 1988). But that does not conclusively mean diplodiosis cannot occur elsewhere should Diplodia levels become severe.

Additionally, Diplodia ear rot can cause kernels to be lightweight, thereby reducing yield and nutritional value (Lipps and Mills, 2002). Vincelli (1997) adds that severely affected corn can have test weight losses of up to 35 percent. Compounding this problem is that Diplodia also results in higher levels of foreign material and broken corn because infected kernels and cobs break apart easily in the harvesting process (Woloshuk and Maier, 2000). Lower test weight and higher levels of broken kernels and foreign material will result in heavy discounts at the grain elevator upon delivery. Under current grain standards, it is feasible that a farmer delivering a heavily infected sample could suffer a discount of 30 cents per bushel or more (Woloshuk and Maier, 2000).

Because affected corn kernels suffer high levels of breakage during harvest, storage of grain can be impaired. The broken grain particles reduce the airflow through the grain during drying processes and can result in spoilage in grain bins. Pre-cleaning to remove these fines and foreign material before drying and delivering grain will minimize storage problems and discounts (Woloshuk and Maier, 2000).

Indeed, proper storage of infected corn helps keep Diplodia from growing. If kernels have significant levels of Diplodia damage, the grain should be dried to less than 14 percent moisture as quickly as possible after harvest to prevent further fungal damage (Agrios, 1997). Furthermore, infected corn should not be stored for long periods of time.

Another potential problem with storage of Diplodia-infected corn involves worker safety. The moldy grain can form clumps in the grain bin, posing a threat to anyone who enters the bin to unload it. If the spoiled, infected grain should seal over and then give way with someone standing on top of it, the worker could be pulled into the grain flow and possibly buried and suffocated (Kingman, 2001).

Management

While crop damage can be extensive, there are management options which can be implemented to help control Diplodia ear and stalk rot. It is known that corn following corn favors the disease, along with rainy weather at silking (White, 1999). A producer can't predict or alter the weather, but can utilize crop rotation for benefits. Since corn is the only known host for this pathogen in the U.S., rotation into another crop, even for only one year, can help deplete the level of inoculum in the field (Vincelli, 1997).

Additionally, tillage practices can decrease the incidence of Diplodia infections. Because the pathogen overwinters on corn residue at the soil surface, tillage practices that bury the corn residue will lower the level of inoculum. It is no coincidence that the occurrence of Diplodia ear and stalk rots were greatly reduced with fall tillage practices in the 1960's and 1970's only to increase later with the prevalence of conservation tillage (White and Malvick, 2001). However, use of fall tillage practices depends on the potential for soil erosion to occur. Deep tillage may not be an option for many producers farming highly erodible land who are enrolled in conservation programs. Therefore, crop rotation takes on more importance as a control option for these acres.

Hybrid selection is another very important aspect in the management of Diplodia. There are no known hybrids available commercially that are resistant to this pathogen (Vincelli, 1997). Very little research has been conducted examining resistance (White, 1999). However, corn hybrids vary in their susceptibility to Diplodia (White, 1999). Good traits such as stalk strength, tight husks and angled ears might prove beneficial to helping keep pathogen injury to a minimum (Partridge, 1997).

Yet other management considerations include implementing balanced soil fertility. It is especially important to avoid conditions of very high levels of nitrogen and very low levels of potassium (Partridge, 1997). Optimizing plant populations that aren't too high can prove beneficial as well (Partridge, 1997). These factors will aid in reducing other plant stresses.

Summary

As previously stated, the incidence and severity of Diplodia infections are closely tied to the environmental conditions at silking. Therefore, predicting levels of any future infections and injury becomes difficult. But clearly, Diplodia has benefitted from the widespread adoption of conservation tillage practices. With the continued use of these practices across a wide geographic area, the incidence and severity of Diplodia could very well increase dramatically in the future. One area which could most potentially be affected is corn breeding. Susceptible inbreds could pass infection on in their seed (Koehler and Holbert, 1930). It was noted in 1930, at a time when Diplodia was prevalent, that infections as high as 30 percent were noted in seed corn (Koehler and Holbert, 1930). In those years, the annual loss in yield was estimated to be 2 percent (Koehler and Holbert, 1930). Diplodia seedling blight attacks the roots or mesocotyl, causing reduced stands, decreased vigor of the seedling and even death (Koehler and Holbert, 1930). Plants from infected seeds that do reach maturity are generally weak and yield poorly (Koehler and Holbert, 1930). Diplodia infected seed fields today could pose a threat to production. Before the advent of conservation tillage, corn breeding programs focused on yield and other agronomic traits. However, with the increase in conservation tillage practices, future breeding programs should identify germplasm resistant to Diplodia ear and stalk rot.

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