STATUS OF APHANOMYCES ROOT ROT IN WISCONSIN

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Introduction

Alfalfa is the primary forage crop in Wisconsin and is a key element in the state's dairy industry. The yield of new varieties is greater than that of Vernal and other older varieties due to genetic gains made by breeders over the years. Much of the yield advantage of new varieties may be attributed to efforts to breed for resistance to a wide variety of major pathogens of alfalfa such as *Verticillium*, *Phytophthora*, and *Aphanomyces*. Although the yield gap has widened between new varieties and Vernal, yield of all varieties has declined steadily in Wisconsin during the past 30 years (Wiersma et al., 1997). There are several possible explanations for this situation including changing climate and the difficulties inherent in dealing with such a genetically diverse crop such as alfalfa. From a pathologist's perspective, new disease-causing organisms or new strains of previously described pathogens may also play a role in limiting yield gains for Wisconsin alfalfa growers. At the University of Wisconsin-Madison, we are conducting research on alfalfa diseases, particularly those caused by organisms that have not been studied previously with respect to their presence and influence on the alfalfa crop. Aphanomyces root rot is one relatively new disease of alfalfa that has been studied in this regard.

Overview of Aphanomyces Root Rot

Although the cause, the fungus *Aphanomyces euteiches,* was reported to infect alfalfa in the 1930's, this organism was considered a minor pathogen of alfalfa. In contrast, Phytophthora root rot, caused by *Phytophthora medicaginis,* was considered the only significant cause of root disease of alfalfa in wet soil situations. Alfalfa varieties resistant to Phytophthora root rot arrived on the scene by the early 1980's and their use resulted in more productive stands especially in wet soil conditions. However, establishment failures would still occur in many fields. This common situation prompted continued research on causes of poor seedling health especially during periods of wet soil conditions. By 1986 evidence was found that *Aphanomyces* caused significant disease of alfalfa seedlings. Much like the situation with Phytophthora root rot, resistance was discovered in alfalfa and almost all new varieties since the early 1990's have good to high levels of resistance to both Phytophthora root rot and Aphanomyces root rot. Studies have noted that isolates of *A. euteiches* tend to be most virulent (i.e., cause the most disease) on the crops from which they have been isolated (Malvick et al., 1998). For example, the alfalfa strain of *A. euteiches* is usually not highly virulent to peas, another common host of this fungus, and vice versa.

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Conditions that Favor Root Rot

Aphanomyces root rot is most severe in flooded soil conditions and often associated with other root rot diseases such as Phytophthora root rot. The discovery of a Phytophthora/Aphanomyces root rot complex was an important first step in the development of alfalfa cultivars that are better adapted for wet soils (Holub and Grau, 1989; Wiersma et al., 1995). Aphanomyces root rot joins Phytophthora root rot as classic examples of diseases of alfalfa grown on imperfectly drained soils, especially in the year of stand establishment (Holub and Grau, 1990). Seedling mortality results in lower yield and, a slow canopy closure which leads to greater weed infestations due to less competition from the alfalfa seedlings.

Symptoms of Phytophthora and Aphanomyces Root Rots

The symptoms of Phytophthora root rot are generally more dramatic and diagnostic when compared to symptoms associated with Aphanomyces root rot (Grau, 1990; Undersander et al., 1994). Alfalfa seedlings at emergence are killed quickly by *Phytophthora*. Taproots of more developed seedlings infected by *Phytophthora* are severed from the upper portion of the root/crown complex. Taproot tissues are blackened at the point where the tissues are severed. Symptoms of Aphanomyces root rot are less obvious and are not characterized by unique alterations of the roots. Infection of young seedlings with *Aphanomyces* can result in the death of seedlings, but more often results in stunted, chlorotic (yellow) plants. Unlike other pathogens which cause seedling collapse, hypocotyls infected with *Aphanomyces* tend to remain rigid, resulting in stunted but upright seedlings (Grau 1990). Infected seedlings initially express chlorotic cotyledons followed by chlorosis of leaf tissues. In most cases, *Aphanomyces* is best described as a chronic pathogen of established alfalfa in contrast to *Phytophthora* (Holub and Grau, 1990). Root symptoms on established plants are typified by a brown decay of cortical tissues. Nodules are frequently absent or are in some stage of decay. Foliage of infected plants becomes chlorotic and resembles symptoms of nitrogen deficiency. Infected plants are often slow or may fail to resume growth after harvest or winter dormancy. *Aphanomyces* is reported to reduce forage yield of alfalfa, but has less of an effect on plant survival (Holub and Grau, 1990) compared to *Phytophthora*.

Current Status of Aphanomyces Root Rot

Effectiveness of Current Forms of Resistance to Aphanomyces

Resistance to *Aphanomyces* has been widely incorporated into commercial alfalfa varieties (Malvick, 1998) and normally means greater forage yield in infested fields. Around 1990, isolates that were highly virulent (i.e., caused significant disease) to breeding lines with resistance to Race 1 were recovered from soils collected in eastern and southern states. Similar isolates were also found in scattered locations in Wisconsin. Such isolates have since been coined “Race 2" isolates and represent a new form of the pathogen. Race 2 isolates of *Aphanomyces* have now been found in Idaho, Maryland, Minnesota, Mississippi, North Carolina, Tennessee, Virginia, Iowa, Kentucky, and Wisconsin (Malvick, 1998). Race 2 is

therefore widely distributed in the United States. In Wisconsin, southwestern counties seem to have a higher incidence of race 2 isolates than other areas. The Lancaster Agricultural Research Station is highly infested with race 2 populations and most isolates from eastern Iowa are also race 2. The race 2 form of *Aphanomyces* was detected in western Dane County and eastern Columbia County in 1999. In each case, alfalfa varieties with race 1 resistance expressed stunted and yellow top growth not only in the seeding year, but also subsequent full harvest years. Varieties with Aphanomyces resistance (race 1) need to be carefully monitored for field performance because the incidence of race 2 in commercial alfalfa fields appears to be increasing in Wisconsin.

Detection of Aphanomyces in Soil

Soils infested with *Aphanomyces* inoculum can be detected by planting bait plants into pots containing the field soil of interest and maintaining flooded conditions for 5 days. Plants with symptoms are then removed from the pots and root tissue from these plants is plated out onto a selective growth medium to obtain pure cultures of the pathogen. The Plant Pathogen Detection Clinic in the Department of Plant Pathology offers a service to assay soils for Aphanomyces. The assay has been modified to determine which race is prevalent in the soil.

Chemical Control

Fungicides containing metalaxyl (i.e., Apron) are not active against *Aphanomyces euteiches* and therefore, avoiding poorly drained soils and using resistant varieties are the main methods useful for control. Apron is effective against Phytophthora and most newer alfalfa varieties are treated with the product for this reason.

Future Considerations

Alfalfa Breeding Efforts

Alfalfa breeding programs are developing lines that are resistant to race 2 of *Aphanomyces* (Malvick, 1998). Fortunately, these lines also appear to be highly resistant to race 1 isolates as well. The time frame for the development of resistant populations of the pathogen is unclear, should be available in one year.

Aphanomyces Races

Race 2 resistant varieties should show the most pronounced effects where race 2 populations of the pathogen predominate. However, even in regions where race 1 populations predominate now, race 2 may become more prevalent in the future if there is selection pressure by the crop (i.e., growing race 1 resistant varieties). Current evidence suggests that race 2 is present before race 1 resistant varieties are planted and race 2 is not emerging in response to race 1 resistant varieties. However, the variability that is present in populations of *Aphanomyces* implies that alfalfa breeders must continue to be vigilant to meet the

demands of controlling this changing alfalfa pathogen.

Performance of Race 2 Resistant Experimental Alfalfa Selections

In most cases breeding efforts against race 2 are occurring in greenhouse environments. Data are not available to confirm that race 2 resistance will be relevant in field situations. The Lancaster Agricultural Research Station is highly infested with Aphanomyces race 2 and serves as a site to field test experimental alfalfa lines selected for resistance to race 2. An experiment was started in 1998 to test the field performance of WAPH-4 (resistant to race 1 and race 2) compared WAPH-1 (race 1 resistance) and Columbia 2000 (susceptible to race 1 and race 2). The yield of WAPH-4 was superior to the other alfalfa selections for one harvest in the establishment year, two harvest the first full harvest year and total yield of both years (Fig. 1). This experiment provides evidence that race 2 is capable of reducing forage yield and that alfalfa lines with resistance to race 2 will yield more than susceptible ones in the presence of race 2 of *Aphanomyces*. Phytophthora root rot was concluded not to have a substantial effect on forage yield. The total yield of WAPH-4 was 1.0 ton/acre more than WAPH-1 even though WAPH-1 has high resistance to Phytophthora root rot (Grau, 1992) and WAPH-4 has moderate resistance to Phytophthora root rot. Further evidence is that forage yield of WAPH-1 and Columbia 2000 were equal, yet Columbia 2000 is susceptible to both Phytophthora root rot and Aphanomyces root rot.

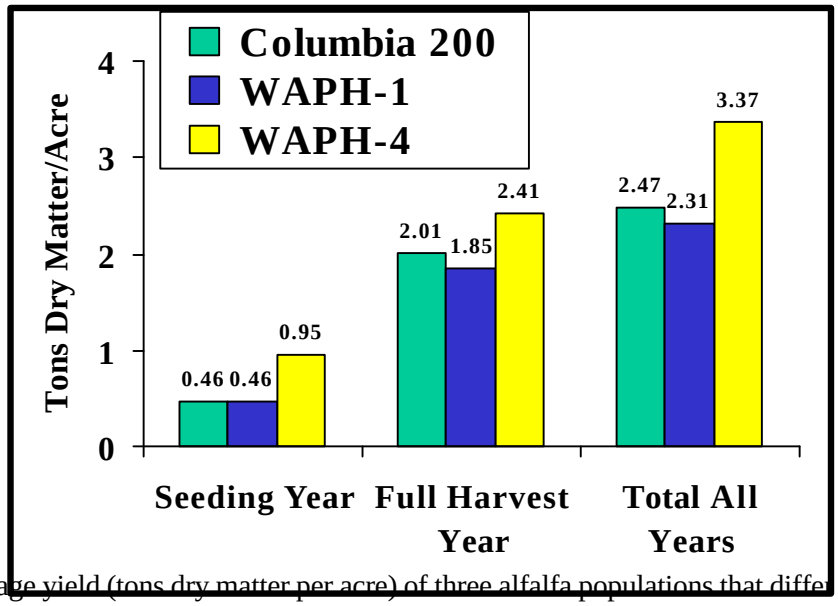

Figure 1. Forage yield (tons dry matter per acre) of three alfalfa populations that differ in reaction to races of *Aphanomyces*. The alfalfa populations are characterized for reaction to *Aphanomyces* as follows: WAPH-4 (resistant to race 1 and race 2), WAPH-1 (resistant to race 1) and Columbia 2000 (susceptible to race 1 and race 2). Experiment was conducted at the Lancaster Agricultural Research Station. Plots were established in May 1998. Harvest data are from one yield in seeding year and two harvests in the first full harvest year. Yield data from D.J. Undersander, Department of Agronomy, University of Wisconsin-Madison.

Summary

Aphanomyces is a widespread pathogen of alfalfa in Wisconsin and neighboring states and is capable of causing lower forage yield.

Two forms of the alfalfa strain of *Aphanomyces* are present in Wisconsin. Race 1 appears to remain most common, but the incidence of race 2 is increasing.

Forage yield was 30% greater for an experimental alfalfa population with resistance to race 2 compared to a race 1 resistant alfalfa population.

Commercial alfalfa varieties should be available in one year with resistance to Aphanomyces race 2.

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