THE OHIO STATE UNIVERSITY EXTENSION

FACT SHEET

Agriculture and Natural Resources

PP401.07

This is the seventh fact sheet in a series of ten designed to provide an overview of key concepts in plant pathology. Plant pathology is the study of plant disease including the reasons why plants get sick and how to control or manage healthy plants.

Fungal and Fungal-like Diseases of Plants

Sarah D. Ellis, Michael J. Boehm, and Thomas K. Mitchell
Department of Plant Pathology

Overview

Collectively, fungi and fungal-like organisms (FLOs) cause more plant diseases than any other group of plant pest with over 8,000 species shown to cause disease. FLOs are organisms like *Pythium* and *Phytophthora* and those that cause downy mildew that until recently were considered fungi but due to changes in fungal taxonomy are now in the kingdom Chromista (also called Stramenopila).

The importance of fungi as agents of plant and human disease, producers of industrial and pharmacological products, and decomposers has spurred scientists worldwide to study their biology. The impact that fungi have with regards to plant health, food loss, and human nutrition is staggering. Some of the world's great famines and human suffering can be blamed on plant pathogenic fungi and FLOs. Wheat crops of the Middle Ages were commonly destroyed when the grains became infected with a dark, dusty powder now known to be the spores of the fungus called bunt or stinking smut (*Tilletia* spp.). The potato blight in Ireland and northern Europe, rampant during two successive seasons (1845–1846 and 1846–1847), was caused by the fungal-like organism *Phytophthora infestans*. The genus itself, *Phytophthora*, was named by Anton de Bary in 1876 as "plant destroyer." This single organism caused the death of more than 1 million people by starvation and initiated one of the largest human migrations on the planet. In the 1870s, an epidemic of downy mildew, caused by the fungus *Plasmopara viticola*, struck the grape vineyards of central Europe, causing great losses to grape growers and wine makers. In the United States alone, hundreds of millions of bushels of wheat have been lost in epidemic years to stem rust (*Puccinia graminis tritici*).

In addition to being agents of preharvest and postharvest diseases and rots, fungi produce highly toxic, hallucinogenic, and carcinogenic chemicals that not only affected the lives of millions historically, but continue to be problems today. In 2006, dozens of dogs perished from food tainted with aflatoxin, a chemical produced by several *Aspergillus* species. These fungi can grow on corn and fill the seed with the toxin that not only attacks the liver, but is one of the most carcinogenic substances known.

Morphology

Fungi and FLOs are eukaryotic organisms that lack chlorophyll and thus do not have the ability to photosynthesize their own food. They obtain nutrients by absorption through tiny thread-like filaments called ***hyphae*** that branch in all directions throughout a substrate. A collection of hyphae is referred to as mycelium (pl., mycelia). The hyphae are filled with protoplasm containing nuclei and other organelles. Mycelia are the key

Figure 1. Botrytis on raspberries. Notice the dusting of gray spores. *(Photo courtesy of P. R. Bristow, copyright the American Phytopathological Society)*

diagnostic sign associated with diseases caused by fungi and FLOs. Most of us have seen mycelium growing on old bread or rotten fruit or vegetables and may have referred to these organisms collectively as molds or mildew.

Fungi and FLOs (indeed all pathogens) can be grouped into the following four categories based on their preference for surviving on dead or decaying organic matter versus living tissue:

1. ***Obligate saprophytes***—always a saprophyte. These organisms can only survive or are obliged to gain nourishment by colonizing dead or decaying organic matter. They are not parasites.
2. ***Obligate parasites***—always a parasite. Can only grow as a parasite on or in a living host. They cannot survive as saprophytes or be cultured in the laboratory. This is a very interesting group of pathogens in that they have a vested interest in prolonging the life of their host to increase their own viability. All viruses, downy mildews, powdery mildews, rusts, and smuts are obligate parasites.
3. ***Facultative parasites***—usually survive as a saprophyte but have the ability to parasitize and cause disease under certain conditions. Examples include *Pythium* species and many bacterial pathogens.
4. ***Facultative saprophytes***—usually survive as a parasite but have the ability to live on dead and decaying organic matter under the right conditions. Examples include *Phytophthora* and *Botrytis* species.

Some fungi and FLOs are able to live on only one host species, while others develop on many different kinds.

Beneficial Fungi

Fungi and FLOs can be beneficial as well as pathogenic. Beneficial fungi participate in biological cycles such as decaying dead animal and plant materials converting them into nutrients that are absorbed by living plants. Some beneficial fungi grow in a symbiotic relationship with the root cells of higher green plants; this life style is termed ***mycorrhizal***. Roots of most cultivated plants—corn, soybeans, cotton, tobacco, peas, red clover, apples, citrus, pines, aspens, birches, turfgrass species, and others—have mycorrhizal relationships with soil fungi. The mycorrhizae appear to be highly beneficial, often necessary, for optimum growth of many plants. Some beneficial fungi, such as those belonging to the genus *Trichoderma*, are effective biocontrol agents of plant pathogenic fungi while others, like *Arthrobotrys dactyloides*, have been shown to trap and parasitize plant pathogenic nematodes.

Certain fungi produce useful antibiotics and enzymes. *Penicillium* fungi produce the famous penicillin G, which has prevented countless deaths from bacterial infection, acting by inhibiting formation of the bacteria's cell wall. Many food-producing processes, such as the making of bread, wine, beer, and cheese, are based on the activities of fungi. Most notably, mushrooms, which are fungi, are an important food for humans, animals, and insects.

Pathogen Biology

Because of the shear number of plant diseases caused by fungi and the huge diversity in how plant pathogenic fungi cause disease, it is impossible and beyond the scope of this publication to provide details about specific disease cycles and integrated fungal disease management strategies. But similar to all other groups of plant pathogens, fungal pathogens have developed ways to survive periods of unfavorable environmental conditions or in the absence of a susceptible host, spread, infect, grow, and reproduce on and within plants. The steps involved in a fungal or FLO's disease cycle are identical to those described previously for bacterial pathogens. One important difference between fungi and FLOs vs. bacteria and viruses, however, is fungi and FLOs can not only penetrate a host via a wound or natural opening but they can also actively penetrate via the production of specialized hyphal structures called appresoria (sing., appresorium). Appresoria are swollen tips of hyphae that allow the fungus, through mechanical and enzymatic activity, to directly penetrate plant tissues. The ability of fungi and FLOs to

Figure 2. Fruit rot caused by the pathogen Rhizoctonia, which also can cause damping off, root rot, and stem cankers. *(Photo courtesy of J. P. Jones, copyright the American Phytopathological Society)*

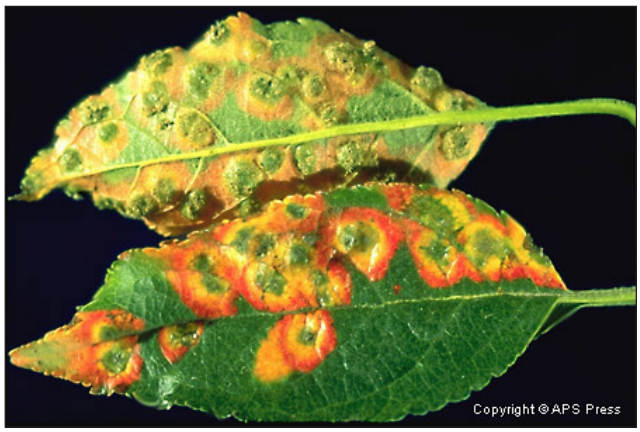

Figure 3. Cedar-apple rust symptoms on the top and bottom of an apple leaf. *(Photo courtesy of D. H. Scott, copyright the American Phytopathological Society)*

Figure 4. Phytophthora root and stem rot of soybean. *(Photo courtesy A. Dorrance, copyright the American Phytopathological Society)*

Figure 5. Brown rot of a peach fruit. *(Photo courtesy D.F. Ritchie, copyright the American Phytopathological Society)*

actively penetrate healthy plants is undoubtedly a contributing factor for their place collectively as the most important group of plant pathogens.

Control

There are generally more options available to professional plant production specialists and growers to manage fungal and FLO diseases as compared to viral and bacterial diseases. One of the most satisfactory methods of dealing with fungus diseases is strict sanitation to eliminate the pathogenic organism, starting with the initial stages of propagation and growth of the potential host plants. Integrated management strategies for fungal and FLO diseases include the following:

1. Genetic Host Resistance

- Using genetically resistant species, cultivars, varieties, and hybrids. In many of the major crops, cultivars resistant to prevailing diseases are available, and more are continually being developed by plant breeders. As has been discussed with other types of diseases, the use of genetically resistant plants, if available, should be the first line of defense for diseases caused by fungi and FLOs. Several examples of cultivars genetically resistant to fungal and FLO disease are notable. Certain hybrid potato cultivars are resistant to late blight (*Phytophthora infestans*). Soybean cultivars resistant to downy mildew (*Peronospora manshurica*) have been developed. In the United States, apple cultivars are available from the Indiana and the New York agricultural experiment stations that show high resistance or immunity to apple scab (*Venturia inaequalis*), a devastating disease of apples grown in cool humid climates with summer rainfall. In the cereal crops (oats, wheat, rye, barley), powdery mildew (*Erysiphe graminis*) can be controlled only by the use of resistant cultivars developed by plant breeders. Tomatoes can be grown in *Fusarium*-infested soils only if *Fusarium*-resistant cultivars are planted. Plant breeders are continuously breeding wheat cultivars resistant to stem rust (*Puccinia graminis tritici*), but the fungus rapidly mutates, attacking the formerly resistant cultivars, requiring new resistant cultivars to be developed.

2. Cultural Practices

- Planting only disease-free certified seed.
- Maintaining a balanced fertility program that avoids excessive or inadequate levels of key plant nutrients.
- Maintaining an effective water management program—maintain adequate soil drainage, monitor irrigation practices, and adjust accordingly, etc.
- Ensuring proper lighting—both quality and quantity to optimize plant health—especially important in turfgrass, floricultural, and ornamental nursery production systems.
- Removing crop residues by burning or burying (plowing).
- Implementing crop rotation strategies to reduce or eliminate the interaction of susceptible plants with pathogens.
- Growing crops in climates unsuitable for pathogenic fungi and FLOs.
- Careful handling of the crop (vegetables and fruits) to prevent cuts, bruises, and wounding during harvest, transit, and storage.
- Storage of crop products at the proper temperatures.
- Soil pasteurization (moist heat at 82 degrees C [180 degrees F] for 30 minutes).

3. Chemical Applications

- The use of preplant soil fumigants, the use of fungicide drenches or seed treatments with fungicides.
- Fungicide applications.
- Postharvest treatment of fruits and vegetables with fungicides.

Although the use of resistant cultivars and eradication of the pathogen through the use of cultural practices are the most satisfactory ways of dealing with diseases caused by fungi and FLOs, in many instances these measures are not possible. Often the disease appears and its development must be slowed or stopped by whatever means are available. Fungicide applications are often essential where there is a demand for plant health during environmental periods that favor pathogen growth. They are typically more effective when applied prior to the onset of disease symptoms (referred to as preventive or preventative applications). Some fungicides are effective when applied after the onset of symptoms and are said to have curative activity. In either case, fungicides must be delivered to the area of the plant where the pathogen is active to be effective. There are many different types and chemical classes of fungicides currently available. Numerous online extension-outreach and agrichemical company resources exist that provide specific fungicide recommendations for nearly every major cropping system and pathogen. Always read and follow label recommendations when applying pesticides.

4. Biological Control

- The use of biological control organisms to suppress the activity of deleterious fungi and FLOs.

5. Government Regulatory Measures

- The implementation of strict quarantines that exclude or restrict the introduction or movement of fungal and FLO pathogens or infected plant material.

For detailed information on each of the IPM strategies, see the fourth fact sheet in this series, "Keeping Plants Healthy: An Overview of Integrated Plant Health Management" (PP401.04).

Introduction to Plant Disease Series

PP401.01: Plants Get Sick Too! An Introduction to Plant Diseases

PP401.02: Diagnosing Sick Plants

PP401.03: 20 Questions on Plant Diagnosis

PP401.04: Keeping Plants Healthy: An Overview of Integrated Plant Health Management

PP401.05: Viral Diseases of Plants

PP401.06: Bacterial Diseases of Plants

PP401.07: Fungal and Fungal-like Diseases of Plants

PP401.08: Nematode Diseases of Plants

PP401.09: Parasitic Higher Plants

PP401.10: Sanitation and Phytosanitation (SPS): The Importance of SPS in Global Movement of Plant Materials

These fact sheets can be found at OSU Extension's "Ohioline" web site: http://ohioline.osu.edu. Search for "Plant Disease Series" to find these and other plant pathology fact sheets.

Links to Fungal Disease Fact Sheets

Dollar Spot of Turfgrass: http://ohioline.osu.edu/hyg-fact/3000/3075.html

Powdery Mildew on Ornamental Plants: http://ohioline.osu.edu/hyg-fact/3000/3047.html

Damping-Off and Root Rot of Beans: http://ohioline.osu.edu/hyg-fact/3000/3110.html

Botrytis Gray Mold on Greenhouse Floral Crops: http://ohioline.osu.edu/hyg-fact/3000/3070.html

Scab of Apple and Crabapple: http://ohioline.osu.edu/hyg-fact/3000/3003.html

Dutch Elm Disease: http://www.apsnet.org/education/LessonsPlantPath/DutchElm/default.htm