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EC1273

Introduction to Plant Diseases

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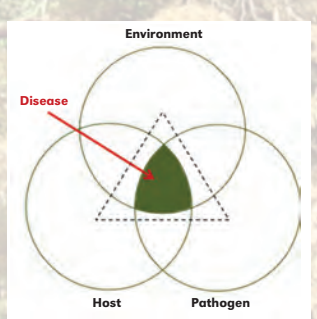

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Plant diseases have impacted society and world history. The great Irish potato famine in 1845 is historically one of the most important human events caused by plant disease. Potatoes infected with Phytophthora late blight caused vines to die prematurely and tubers to rot in the ground and in storage. Because of this disease, approximately 2 million people either starved to death or immigrated to the United States. More recent examples of diseases impacting landscape trees include chestnut blight and Dutch elm disease. Both of these diseases were accidentally introduced to the United States and have caused great economic losses. All plants can be affected by diseases. This publication imparts a basic understanding of how diseases develop. Gardeners and landscape managers will gain an appreciation for the complexity of plant diseases.

Figure 1. Ice damage to trees is an abiotic injury that could potentially produce wounds allowing entry by some plant pathogens.

Plant Diseases

A plant disease is defined as "anything that prevents a plant from performing to its maximum potential." This definition is broad and includes abiotic and biotic plant diseases.

- **Abiotic or non-infectious diseases.** These diseases are caused by conditions external to the plant, not living agents. They cannot spread from plant to plant, but are very common and should be considered when assessing the health of any plant. Examples of abiotic diseases include nutritional deficiencies, soil compaction, salt injury, ice, and sun scorch (*Figure 1*).
- **Biotic or infectious diseases.** These diseases are caused by living organisms. They are called plant pathogens when they infect plants. For the purposes of discussing plant pathology, only plant disease pathogens will be discussed. Pathogens can spread from plant to plant and may infect all types of plant tissue including leaves, shoots, stems, crowns, roots, tubers, fruit, seeds, and vascular tissues (*Figure 2*).

Types of Plant Pathogens

Plant pathogens are very similar to those that cause disease in humans and animals. Fungi, fungal-like organisms, bacteria, phytoplasmas, viruses, viroids, nematodes, and parasitic higher plants are all plant pathogens.

- **Fungi and Fungal-like Organisms (FLOs).** Collectively, fungi and FLOs cause the most plant disease than any group of plant pathogens. These organisms cannot make their own food, lack chlorophyll, have filamentous growth, and may or may not reproduce by spores. Fungi and FLOs are able to overwinter in soil or on plant debris. However, some fungi and FLOs can not overwinter in northern climates because of low winter temperatures. These pathogens overwinter in southern climates and then are transported by air currents back to northern climates. Disease movement from southern to northern

Figure 2. Brown rot of apricot is a biotic disease. The brown fuzzy mass visible on the fruit is the spores that will move to infect a neighboring apricot.

Figure 3. Bacterial blight of geranium caused by *Xanthomonas hortorum pv. pelargonii*. Bacterial lesions are often blocky or angular and later have yellow halos around them. (Photo courtesy of Nancy Gregory, University of Delaware, Bugwood.org)

climates can be monitored during the growing season.

- **Bacteria.** Bacteria are single-celled microscopic organisms with cell walls that reproduce by binary fission (one cell splits into two). Introduction to the plant must occur through natural openings or wounds in the plant. Bacteria overwinter primarily in soil and in or on plant material that does not decompose, but some survive inside insect vectors (*Figure 3*).
- **Phytoplasmas.** Phytoplasmas are microscopic, bacteria-like organisms that lack cell walls and thus appear filamentous (*Figure 4*).
- **Viruses and viroids.** Viruses are intracellular (live inside the cell) nucleic acid particles with a protein coat that infect other living organisms and replicate in the hosts they infect. Viroids are virus-like particles but lack a protein coat. Viruses and viroids are primarily transmitted by vectors including insects, nematodes, and fungi, which introduce the virus or viroid during feeding. Viruses and viroids also can be transmitted through seed, vegetative propagation and pruning (*Figure 5*).
- **Nematodes**. Nematodes are microscopic worm-like animals. The majority of nematodes are soil dwelling animals and move with soil. However, there are some nematodes that are transmitted through insects and infect aboveground plant parts (*Figure 6*).
- **Parasitic higher plants.** Parasitic higher plants are plants that contain chlorophyll but cannot produce their own food. They parasitize other plants to obtain nutrients and water. Examples include mistletoe and dodder (*Figure 7*).

Figure 4. Aster yellows is caused by a phytoplasma and is carried primarily by leafhoppers. As an infected leafhopper feeds on plants, the phytoplasma is injected into the plant. Symptoms, such as the unusual flower growth, are exhibited on plants that have been infected. An infected plant needs to be removed so insects feeding on it will not transfer the phytoplasma to other plants. (Photo courtesy of Anne Streich, UNL Agronomy and Horticulture)

Figure 5. Rose infected by rose mosaic virus which causes mottling of the leaf tissue. This disease is spread by vegetative propagation. (Photo courtesy of Lesley Ingram, Bugwood.org)

Disease Triangle

Three components are absolutely necessary for disease to occur in any plant system:

1. A susceptible host plant
2. A virulent pathogen
3. A favorable environment

When these three components are present at the same time, disease will occur (*Figure 8*).

It is important to remember that within each of the three components — host, pathogen, and environment — there are numerous variables that may affect both the incidence and severity of disease. These variables include genetic diversity, biology and life cycle of the host plant and pathogen, and environmental conditions.

Genetic diversity. Within one species of host plant there may be an incredible range of genetic diversity that greatly influences susceptibility to any particular species of pathogen. If the host is resistant to a pathogen, even when the pathogen is present under favorable environmental conditions, disease will not occur (*Figure 9*). Genetic diversity also plays a role in pathogen virulence or its ability to infect a host and cause disease, which may also influence the amount and severity of disease.

Biology and life cycle of the host plant and pathogen. Host plants may be resistant to pathogens at one stage of development but not at another. In a similar manner, some pathogens must be at a critical life stage in order to cause infection.

Environmental conditions. There are numerous variables in the environment that influence disease incidence and severity including temperature, sunlight, moisture, relative humidity, and time of year. Pathogens are typically restricted to an area based on the conditions of the macroclimate. A macroclimate is the prevailing climatic conditions in a certain geographical area. Within a macroclimate, small areas may exist in which the climate may be different than the surrounding areas. This is called a microclimate. Each landscape is filled with microclimates that exist because of differences in exposure to sun and wind, soil type, and many other factors.

Disease Cycles

In order for disease to develop, a pathogen must be present and successfully invade plant host tissues and cells. The chain of events involved

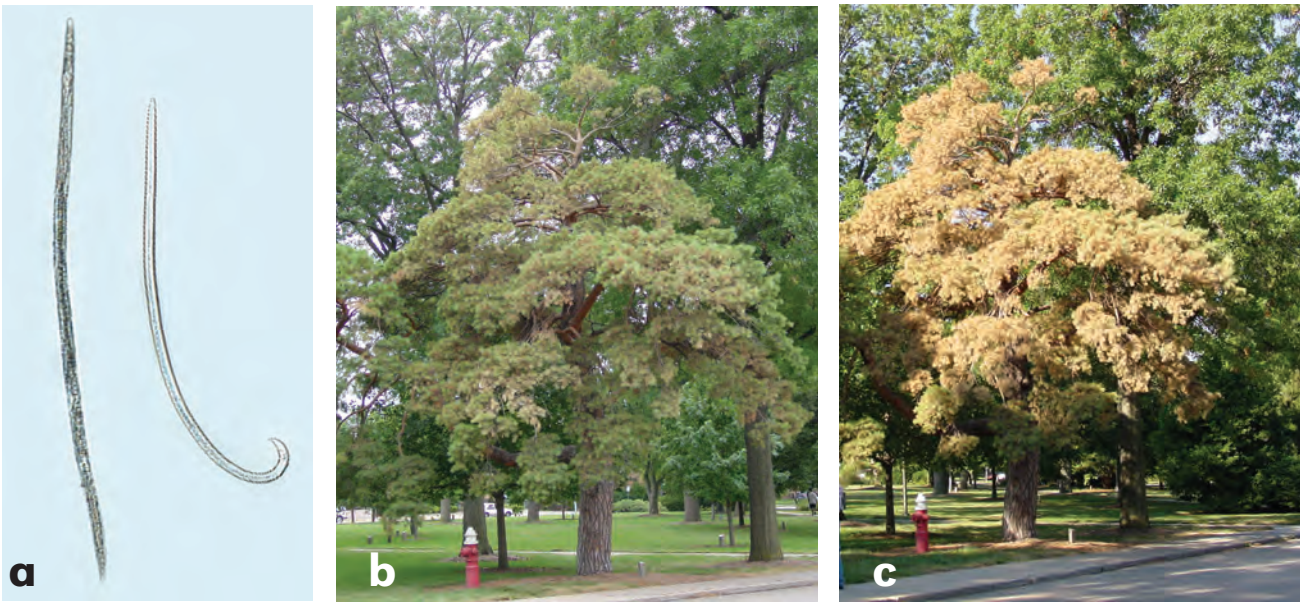

Figure 6. Pinewood nematodes (a) are carried to pines by pine sawyer beetles. Once inside a tree, the nematodes can reproduce quickly and cause complete tree failure within just a few weeks (b and c) — Aug. 20 to Sept. 2. (Photos b and c courtesy Laurie Stepanek, Nebraska Forest Service)

in disease development includes inoculation, penetration, infection, incubation, reproduction, and survival (*Figure 10*).

- **Inoculation.** This describes the introduction of the plant pathogen to the host. Different pathogen groups employ different inoculation methods and are equipped with various specialized mechanisms that aid in the inoculation process. For example, some fungal pathogens release spores into the air, and the spores are then spread with the aid of air currents.
- **Penetration.** Wound sites and natural plant openings, such as stomata and hydathodes, facilitate the entrance of some plant pathogens; others have evolved unique mechanisms for direct penetration. Fungi and nematodes are able to actively penetrate host tissues and cells if environmental conditions, such as moisture and temperature, are favorable for the penetration process.
- **Infection**. This occurs when the pathogen invades the plant tissue

Figure 7. Dodder is a parasitic plant with slender stems that twine around its host plant. It penetrates the host's vascular system to get nutrients and water needed for growth. It is very difficult to control. (Photo courtesy of Backyard Farmer viewer submission)

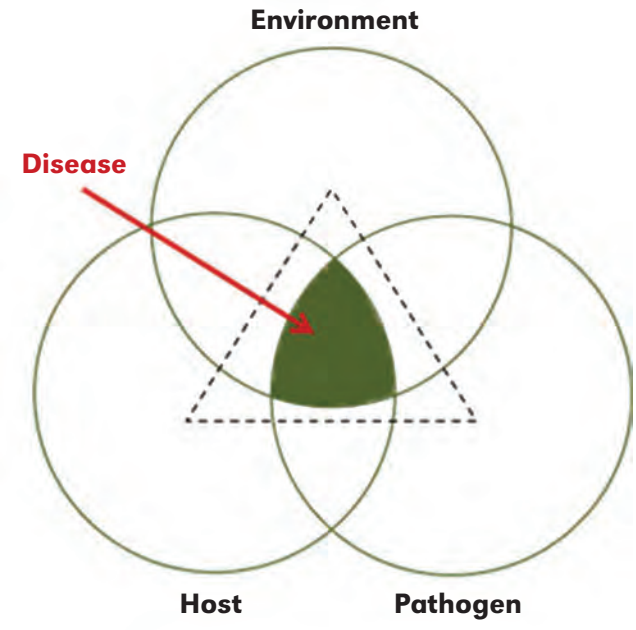

Figure 8. Disease (shaded region) will occur if a susceptible host plant is in intimate association with a virulent plant pathogen under favorable environmental conditions. This concept is represented by the shaded portion of the diagram above. When there is a high degree of overlap (as the shaded area becomes larger), there will be a moderate to high amount of disease.

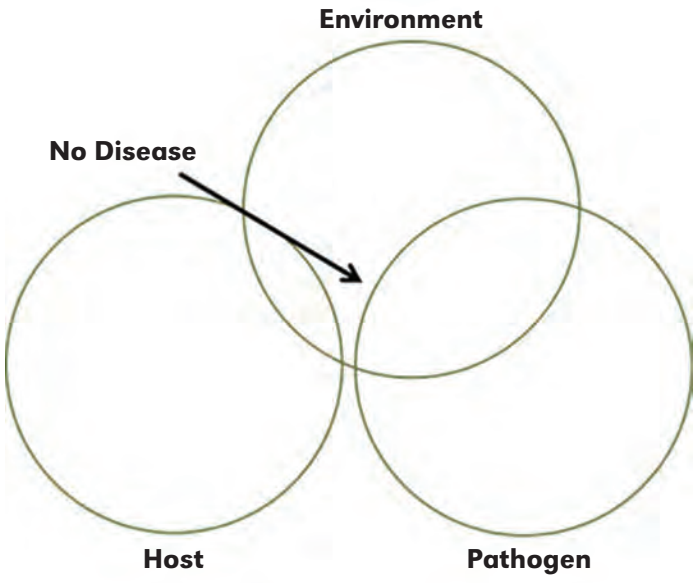

Figure 9. Variables within each component of the disease triangle may affect the presence of disease. This diagram represents a system in which the host is displaying resistance to disease even in intimate association with the pathogen under favorable environmental conditions.

and establishes a parasitic relationship between itself and the plant. Viruses, bacteria, and phytoplasmas are not able to actively penetrate or enter plant host tissues; therefore, they must rely on other methods to infect plant tissues and cells. Associations with insect vectors have been established by these pathogens to aid inoculation and dispersal.

- **Incubation.** Once inside the plant, pathogens may undergo an incubation period and remain latent for a period of time before initiating disease.
- **Reproduction.** Plant pathogens can reproduce sexually and asexually. It is dependent on the pathogen.
- **Survival.** Plant pathogens have evolved so they can survive prolonged periods of unfavorable weather conditions. For example, diplodia tip blight, affecting pine, is a fungal pathogen that produces spores that are dark in coloration, which reduces the amount of UV light penetrating and preventing cell death. In addition, some nematode species will lay their eggs within a cuticle casing. The cuticle casing is very hard and prevents other microbes and chemicals to penetrate killing the eggs prior to hatching.

If any step is disturbed in the cycle, the disease will be less severe or fail to develop. Knowing and understanding the disease cycle for a particular disease is very helpful in managing the disease. There are two types of disease cycles — monocyclic and polycyclic.

- **Monocyclic pathogen diseases.** These pathogens complete their life cycles once in a season. Cedar-apple rust is an example.
- **Polycyclic pathogen diseases.** These pathogens complete their life cycles multiple times during

a season resulting in secondary infections as the growing season progresses. Black spot of rose is an example.

Integrated Plant Management and Plant Diseases

Plant disease management is best accomplished through integrated pest management (IPM) techniques. IPM uses a combination of methods to achieve disease control, such as using disease-resistant plants, removing diseased plants or plant parts, placing plants in the correct environmental conditions and, when necessary, using chemical controls. To choose the best option for treating a plant problem, gardeners and landscape managers should follow these steps:

- Correctly identify the plant(s). Know the visual characteristics and healthy growth habit of each plant. For example, the variegated, chartreuse, or yellow foliage, of some plants can be misdiagnosed as scorch or a nutritional deficiency.
- Monitor pests and damage. For more information on how to describe the injury being observed, refer to the EC1270, *Common Symptoms and Signs of Unhealthy Plants*.
- Identify the pathogen and understand the disease cycle.
- Determine if there is a threshold level above which treatment is necessary.
- Consider all the control methods available, including replacing the affected plants with varieties that are resistant, removing damaged plants or plant parts, changing cultural practices, implementing biological techniques, or applying chemical control.

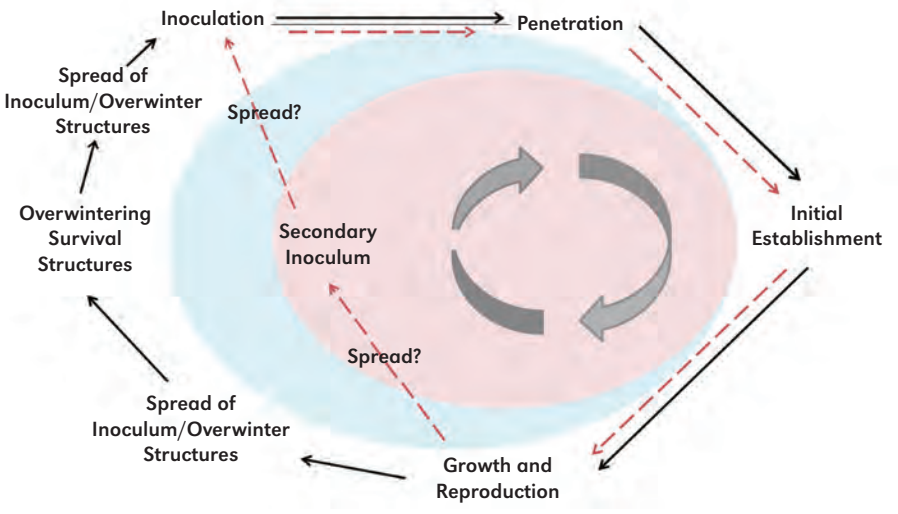

Figure 10. The monocyclic pathogen follows the black arrows to complete its cycle. Polycyclic pathogens follow the red arrows for the majority of the season and the black arrows at the end of the season.

Gardeners and landscape managers have the most influence on the host. Selecting plant material that is resistant to various diseases and placing those plants in the right location reduces plant stress, which can limit the potential for disease susceptibility. Good sanitation practices such as removal of diseased leaves and twigs from the ground and pruning or removing diseased branches and stems from plants will reduce pathogen populations. The use of fungicides is unnecessary for most diseases found in landscapes. However, there are circumstances when fungicides are a necessary part of the IPM scheme, such as the treatment of black spot in non-resistant heirloom rose varieties. Changes to the environment can be made by modifying watering practices to reduce leaf wetness and disease organisms from splashing onto plants. Modifying planting distances can reduce humidity or increase wind penetration in landscape microclimates.

Summary

There are many types of organisms that cause plant diseases, but fungi are the most common cause of diseases in landscape plants. A susceptible host plant, a virulent pathogen, and a favorable environment must be present for plant diseases to occur. The amount of overlap among these three components determines the severity of the disease. A specific chain of events must occur for diseases to develop. This process includes pathogen inoculation, penetration, infection, incubation, reproduction, and survival. Gardeners and landscape managers will need to manipulate at least one of the disease components to reduce disease severity in landscapes.

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