Understanding the Basics of Plant Disease for Effective Disease Management

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Dr. Roberts retired from Michigan State University in 2018 after committing four decades to advancing MSU's Land Grant Mission, originally signed into law by President Abraham Lincoln during the midst of the American Civil War. He has published hundreds of articles and has taught hundreds of lectures and workshops.

Dr. Roberts has researched many issues in Michigan's plant industry, including Oak Wilt, Dutch Elm Disease, Diplodia Tip Blight of Pines, along with a variety of cultural problems such as plant nutrition and herbicide toxicity. During his career, he has discovered a variety of new diseases and pests such as Phomopsis Canker of Spruce and the first bacterial wilt disease of turfgrasses in North America.

In the early 2000s, his research on Ash Decline in Southeast Michigan led to the discovery of the invasive Emerald Ash Borer in North America.

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True or False: Tar Spot on Norway Maple, Scab and Fire Blight on Crabapple, Needlecast on Spruce, and Trellis Rust on Bradford Pear are affecting trees at Bob Seger's country home known as "The Silver Bullet" Estate near Metamora, Michigan. Anxious Tree Service (a fictitious name, gulp, I hope) proposes that three sprays of fungicides, one in May, one in June and one in July, will control all diseases on the Silver Bullet Estate *(answer at the end of this article).*

Introduction:

Phytopathology (aka Plant Pathology) is the study of Plant Diseases. Over many years, I have encountered a variety of misunderstandings about specific diseases from the public and professional plant health care providers alike. Part of the reason for these misunderstandings may be that there is a plethora of what might be termed "Fake News" on the web. For example, regarding the introduced, invasive Trellis Rust, numerous websites advise raking and destroying fallen leaves (not putting them in the compost) so that the Trellis Rust fungus cannot survive overwinter on these fallen leaves; the Trellis Rust fungus survives overwinter on *Juniperus*, not on pear leaves. It might also be the case that we do not review the nuances of diseases and pests and their specific differences. Hence, I thought it might be useful to review the disease cycles of what might be termed "Classic Diseases", diseases that we commonly encounter and try to manage in this industry. This article may be pertinent given the upcoming spring season when we must consider the management of many diseases in the landscape and nursery. These examples are by no means exhaustive of all of the examples we may encounter, but I think they serve to provide representations of the variety and variations of plant diseases that are quite common. Please forgive me if the following information is more than you would ever want to know about Plant Diseases, but, if nothing else, this will be a good article to keep by your bedside as a sleep aid.

First, Some Terms:

To better understand plant diseases and their management, it is important that we understand some basic terminology regarding the field of Plant Pathology. I hope readers' eyes do not glaze over when reading and comprehending a few of these basic scientific terms.

Plant Pathogen: An organism (usually microorganism aka microbe) that causes ***infectious*** Plant Disease. These microbes are typically fungi, bacteria, viruses, nematodes and phytoplasmas, etc. "Infectious Diseases" are typically differentiated from "Abiotic Diseases", which are not caused by infectious agents. "Abiotic Diseases" may be initiated by abiotic (nonliving) instigators such as nutritional disorders, weather conditions, and cultural issues such as misapplication of an herbicide, etc.

Obligate Parasite: A plant pathogen that must be able to attack, live, and survive on a living host plant. Such an organism (microbe) is "obligated" to survive on a living host plant, not on dead plant material as a saprophyte might.

Facultative Saprophyte: A plant pathogen that attacks a living host plant, but which can spend part of its life/disease cycle living on dead plant material as a saprophyte rather than a parasite.

Monocyclic: A disease that has one cycle per year. Typically, monocyclic diseases begin in the spring by attacking newly emerging foliage from overwintering structures residing on dead or living plant material.

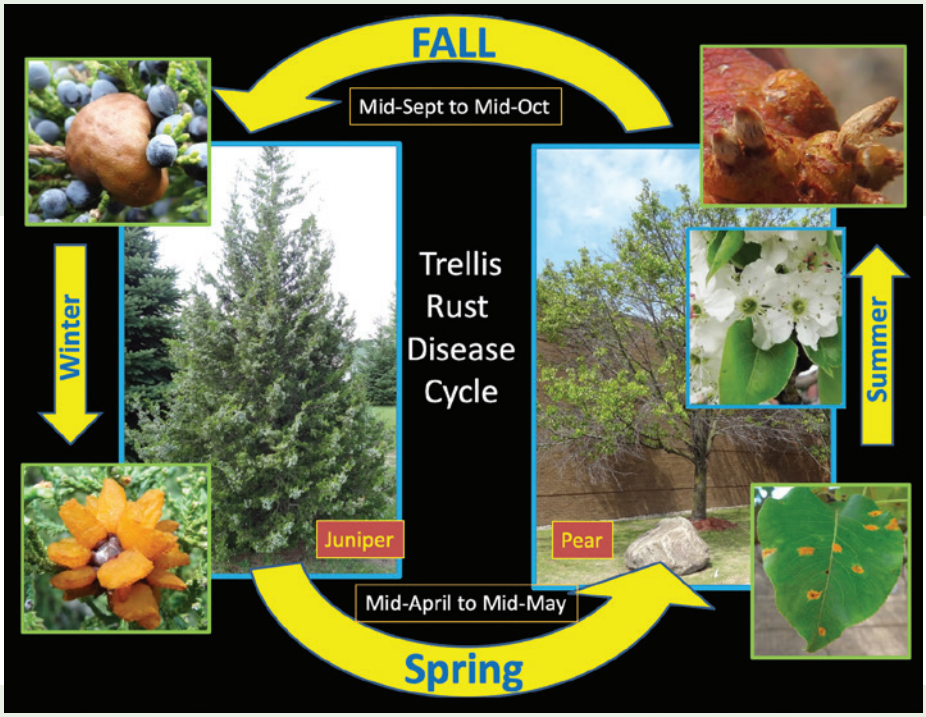
Multi-Cyclic: A disease that typically has repeating stages of attacking plant tissue during the same year.

Fungicide Mode of Action: Although there are a variety of modes of chemical fungicide action, in a general sense, fungicides (despite the "cide" = death) protect the foliage from infection and do not kill the fungal pathogens, per se. Fungicides might more properly be termed "fungistats" because they prevent infection and do not kill the organism.

Disease/Life Cycle: Disease and/or Life Cycles portray what the plant pathogen does throughout the year. Disease and Life Cycles may technically be different but are combined herein for ease of communication. Cycles may be single or multiple each year depending on the characteristics of the disease agent and the disease it causes. Disease Cycles are often presented in a circular, annual display with some detail such as that shown for Trellis Rust in Schematic #1.

Specific Diseases, Their Cycles, and Their Management:

The following examples are common diseases that may be termed "Classic" examples of diseases that can serve as representatives of some of the various disease characteristics and cycles that we may encounter in the landscape and nursery. On some occasions, two or more diseases may occur on the same plant (Photo 1).



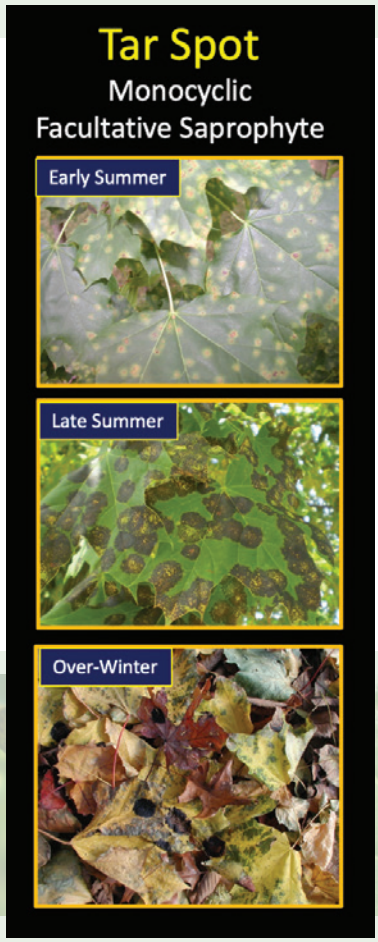
P1 It is not unusual for trees and other landscape plants to be affected by multiple diseases and/or pests. In the photo on page 42, Norway maple is affected by Tar Spot (monocyclic, facultative saprophyte) and powdery mildew (multi-cyclic, obligate parasite). Neither disease is likely to cause serious harm to the tree despite their objectionable appearance.

Schematic #1 – Disease Cycles are often summarized in a circular annual schematic such as denoted here for Trellis Rust. For ease of presentation, the Disease Cycle for Trellis Rust can also be presented in a simpler form such as shown in Schematic #2.

Trellis Rust: Obligate Parasite, Monocyclic (Schematic #2)

Rust fungi are typically considered obligate parasites because they cannot live on or obtain their nourishment from dead organic matter or dead plant material. They are *obligated* to attack and survive only on living plant material. Trellis Rust, caused by *Gymnosporangium sabinae,* attacks pear trees from "blooming galls" on its alternate host, *Juniperus,* in the spring… generally from mid-April through mid-May, depending on weather conditions in the spring. It causes yellowish lesions on pear leaves (1st Photo). Later in the fall, structures opposite the yellow lesions release spores from the undersides of the pear leaves (2nd Photo) that attack and cause overwintering galls (3rd Photo) on junipers. As a monocyclic disease, the only opportunity for control is in the spring on pear trees (mid-April through mid-May, typically) and in the fall on junipers (mid-September through mid-November, typically). Applying fungicides outside of these two narrow windows will provide no efficacy for disease management.

Schematic #2 – The disease cycle of Trellis Rust is also briefly summarized here in the major events of the fungus' life cycle in relation to its two host plants. While the fungus attacks pear trees during the warm season, it overwinters on junipers. The fungus does not overwinter on fallen pear foliage as many websites suggest.



Tar Spot: Facultative Saprophyte, Monocyclic (Schematic #3)

As with many other diseases, the Tar Spot fungus *(Rhytisma)* attacks newly emerging maple foliage in the spring from overwintering structures on fallen dead leaves from the previous year. Typically, smallish yellow spots are the first symptom noted (1st Photo). As the season progresses, the spots continue to enlarge and become very dark in color due to development of fungal material (2nd Photo). The fungus overwinters on fallen, dead foliage (3rd Photo). Each spot arose from one spore infection in the early spring. In contrast to scab on crabapple, there are no repeating phases of infection through the summer with Tar Spot. Hence, although not often recommended because the fungus is not seriously detrimental to its primary host trees (Silver and Norway maples), the only time in which fungicides may protect the foliage from infection is in the early spring, not after the initial infections and spots have appeared.

Schematic #3 – Tar Spot is a monocyclic disease. The fungus (*Rhytisma* sp.) attacks maple leaves in the early spring near budbreak. Each yellow spot that develops in the early summer (later expanding to large dark spots) is the result of one spore infection. Treatments after the initial infection will not be efficacious.

<u>Scab of Apple & Crabapple:</u> Facultative Saprophyte, Multi-Cyclic (Schematic #4)

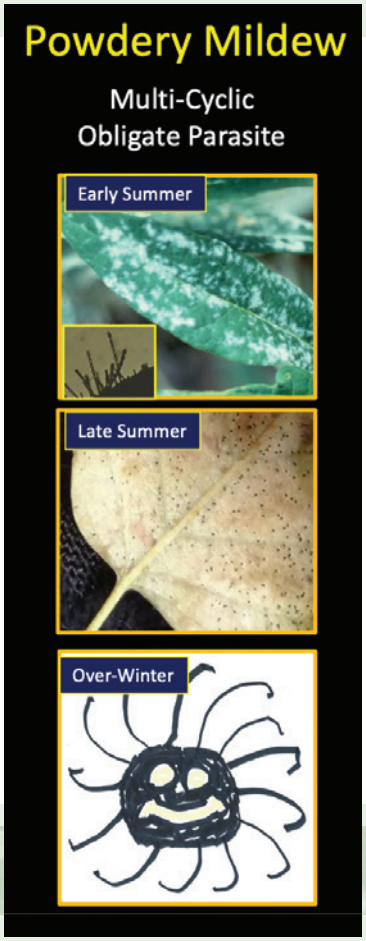
Scab, caused by *Venturia inequalis,* typically affects newly emerging foliage in the spring from overwintering structures on dead leaves (3rd Photo). Once the fungus causes scab lesions on the new foliage in the spring, the fungus continues to infect new and older foliage in repeating cycles, causing more and more lesions on foliage as the season progresses (1st Photo). Defoliated trees (2nd Photo) by August are not uncommon, leading to an erroneous conclusion that apple/crabapple trees have died (they haven't). Although fungicide applications are preferred in the early spring to inhibit the first infections, thus confounding repeating phases throughout the year, fungicide applications may also be beneficial in early to mid-season to lessen the disease buildup over the summer.

Schematic #4 – Scab of crabapple and apple initially attacks in the early spring and subsequently produces spores on those freshly attacked leaves that can spread to other foliage in a repeating phase throughout the warm season. The fungal pathogen overwinters on dead, fallen leaves.

<u>Powdery Mildew:</u> Obligate Parasite, Multi-Cyclic (Schematic #5)

There are a variety of Powdery Mildew (PM) diseases that are generally specific for their host plants. PM also typically attacks newly emerging foliage (1st Photo) from overwintering structures on foliage that was shed the previous fall (2nd Photo). PM is considered an obligate parasite because it cannot gain nourishment or continue to develop on dead foliage. Unlike Tar Spot and Trellis Rust, the Powdery Mildew fungus can produce spores (conidia) that can be wind-borne to new foliage throughout the summer season, representing a multi-cyclic disease. Later in the season, the fungus produces specialized tiny dark structures (Cleistothecia, 2nd Photo) on the undersides of foliage that enable the fungus to survive on the dying, shedding foliage in the fall and winter (Note: artist rendering of how tiny cleistothecia may appear under a magnifying device, 3rd Photo). As an obligate parasite, the fungal cleistothecia simply use the dead foliage as a surface to release spores the following season (it does not use the dead foliage as a food substrate).

Schematic #5 – As an obligate parasite and like most obligate parasites, the Powdery Mildew fungus is specific for its host plant. In other words, there are many different species or strains of the fungus, each of which only recognizes its primary host plant. During the summer, the white mold contains spores (conidia, 1st Photo Inset) that may spread by wind and infect new foliage (1st Photo, Tall Phlox). As its host plant's foliage senesces in the fall, specialized overwintering structures (cleistothecia, note tiny, barely visible spheres to the naked eye on birch, late summer, 2nd Photo) are formed that utilize the falling, dying leaves as a surface, from where the fungus releases spores the following spring to attack newly emerging foliage of its host plant. Bottom sketch (3rd Photo) is of an artist rendering (facsimile) of an enlarged, overwintering cleistothecium.



<u>Rhizosphaera Needlecast of Spruce:</u> Facultative Saprophyte, Multi-Cyclic (?) (Schematic #6)

Rhizosphaera survives overwinter on fallen foliage (needles) beneath spruce trees (3rd Photo, tiny dark structures emerging from needle stomates) and typically attacks previous years' needles in the spring, often before the new growth emerges (1st Photo). Later in the season, infected needles are "cast" from trees, largely leaving the current year's needles unaffected (2nd Photo). The primary infection usually takes place as a "monocyclic" disease in the spring but on occasion, when environmental conditions are favorable, the fungus may attack spruce foliage at other times of the growing season, essentially making it a potential multi-cyclic disease.

Schematic #6 – Like many other foliar diseases, Rhizosphaera Needlecast of Spruce attacks previous years' foliage in the spring from previously fallen needles (3rd Photo: note dark fungal reproductive structures on brown needles from beneath spruce trees). Note browning older foliage in the 1st Photo indicating an early spring infection. Cast needles often result in the appearance of primarily new unaffected growth (2nd Photo). Depending on weather/environmental conditions, the fungus may (or may not) subsequently attack again at other opportunities during the growing season.

<u>Fire Blight of Rosacea:</u> Facultative Saprophyte or Obligate Parasite (?), Multi-Cyclic (?) (Schematic #7)

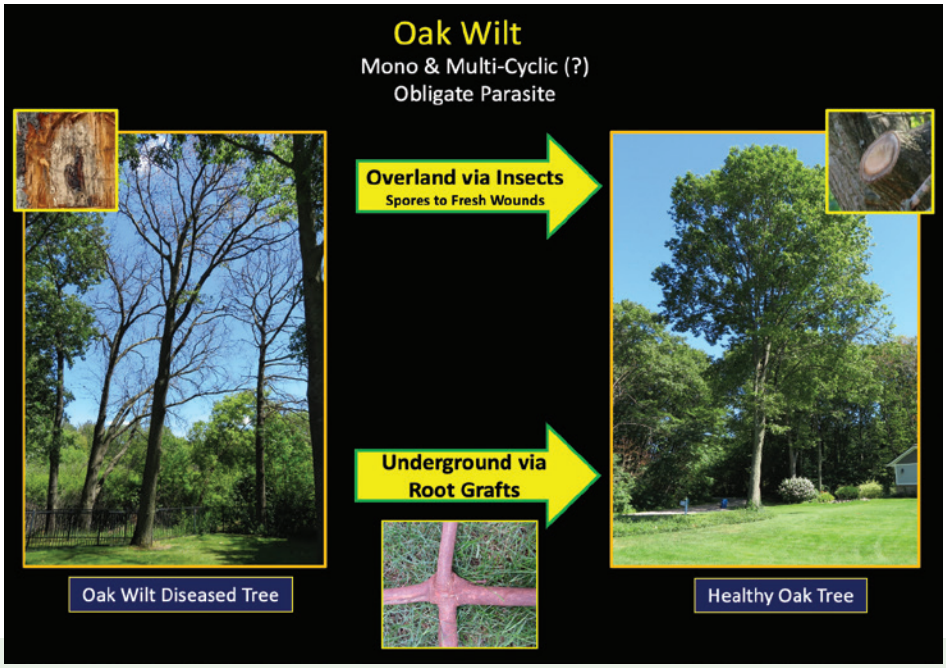
Fire Blight is the only disease included in this group of "Classic Diseases" that is caused by a bacterium. The Fire Blight bacterium, *Erwinia amylovora,* attacks many members of the Rosacea family (apple, crabapple, pear, pyracantha, cotoneaster, mountain ash, etc.). With warming weather in the spring, the bacterium multiplies to billions of bacterial cells where they are water-splashed or insect-transmitted to succulent emerging foliage and flowers (1st Photo). The disease is locally systemic, killing shoots and branches exhibited as "Blight" by "Fire" by late spring and early summer (2nd Photo). The Fire Blight bacterium may attack at other times, especially through wounds (pruning injury, hail damage, etc.). The bacteria overwinter in "holdover cankers" on blighted spurs and branches (3rd Photo), from whence reproducing bacteria are carried by water splashing or insects in the following spring.

Schematic #7 – Fire Blight is caused by the bacterium, *Erwinia amylovora*. Bacteria are among the smallest disease agents, but are still much larger than viruses. The bacterium multiplies into billions of cells during the warmth of spring (1st Photo); the 1st Photo shows the microscopic "gushing" of millions of bacterial cells from a cut stem, which is why pruning infected trees is potentially risky and can spread the disease to uninfected trees/branches. Fire blight infections usually result in blighted shoots/spurs by late spring or early summer (2nd Photo). The bacterium overwinters in "holdover cankers" (3rd Photo). A rather effective control strategy is to carefully prune out these holdover cankers during the winter months.

<u>Oak Wilt:</u> Obligate Parasite, "Multi-Cyclic" (Schematic #8)

Oak Wilt is the only vascular wilt disease presented in this group of "Classic Diseases". Dutch Elm Disease and Verticillium Wilt are examples of other wilt diseases. Oak Wilt spreads from diseased trees (Left Photo) to healthy trees (Right Photo) by two major means: 1) **<u>Overland</u>** via insects (sap beetles) from fungal pressure pads (Left Photo Inset) to fresh wounds (Right Photo Inset) in healthy trees, and 2) **<u>Underground</u>** via root grafts (Lower Middle Photo) between nearby diseased and healthy trees. **Overland Spread** typically takes place during the spring and early summer. Theoretically, **Underground Spread** may take place any time of year. Because Oak Wilt is a rather complex disease with many nuances, I should refer readers to other articles published in *The Michigan Landscape.*

Schematic #8 – Oak Wilt, caused by the fungus *Bretziella fagacearum,* is disseminated from fungal spore mats on diseased trees (Left Photo and Inset) to injuries on healthy trees (Right Photo and Inset) by two major means, Overland by insects and Underground through root grafts (Lower Center Photo). The fungus may survive in diseased trees for extended periods, especially in roots. Survival of the fungus in pressure pads beneath the bark is relatively short-lived. The disease is lethal on members of the Red oak family and mildly so on members of the White oak family.



Importance of Foliar Diseases:

Foliar diseases rarely cause serious harm to trees or woody shrubs. If we miss the opportunity for control this year, we typically have other opportunities in succeeding years. Possible exceptions to this rule are invasive foliar diseases. Invasive, introduced problems such as Dutch Elm Disease, Emerald Ash Borer, and Dogwood Anthracnose, for example, tend to be more devastating if not lethal than similar acting native issues. The same is true for foliar diseases such as the introduced, invasive Trellis Rust.

Composting & Foliar Diseases:

There are an astonishing number of websites suggesting that leaves infected with Trellis Rust should not be placed in the compost pile. Of the five foliar diseases discussed in this article, Trellis Rust, because it is an obligate parasite that survives overwinter on junipers and not on fallen pear leaves, is by far the safest disease to be composted. In general, ***thorough*** compositing will destroy most foliar disease agents trying to survive overwinter in plant refuse…to infect trees in the following spring. The heating and intense microbial activity of good composting methods lessens the chances of foliar disease pathogen survival. Even if thorough composting is not attained, a pile of leaves (for example, crabapple leaves infected with the Scab fungus) will release far fewer spores than leaves scattered throughout the landscape (leaves buried in a compost pile cannot release spores in the spring to infect newly emerging foliage compared to composting foliage on the surface of the compost pile). Composting will usually have less impact on degrading disease organisms that cause wilts, stem problems, and root issues.

General Disease Management:

When considering disease management, it is vital to perform an accurate diagnosis, thoroughly understand the disease cycle, and consider all options for efficacious disease management procedures. Sometimes, multiple inputs may be best. While the objectives of this article are to relate various disease cycles and the most efficacious time for treatments, we must remember that there are a multitude of techniques that can be applied in an integrated approach for disease management. Using genetically resistant plants, employment of biological or "organic" control products, and modification of the environment through cultural practices such as irrigation adjustments, nutritional inputs, and composting are just a few of the alternative practices that may be adopted in lieu of reaching for that pesticide as the first choice for disease management.

Answer to True or False: False!!

If the first treatment for the above-mentioned plant diseases is in May, then it is very possible that the treatments will miss the initial infection periods for most of these diseases, which typically take place at or near budbreak. Also, fungicides will not generally control bacterial-incited

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diseases such as Fire Blight. As we understand in this article, missing the initial infections of many diseases, especially the monocyclic ones, will not result in satisfactory disease control if the treatments are administered too late. The second or third treatments as Blanket or Cover Sprays for control of monocyclic diseases will not only be ineffective but may be considered unethical.

Dave Roberts is a Presenter at GLTE 2023, held at DeVos Place in Grand Rapids, MI, January 24-26th.

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