Why Infectious Tree Diseases Are Difficult to Manage

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Infectious tree diseases—those diseases which involve not only a tree host but also an infectious pathogen such as certain fungi, bacteria, nematodes, phytoplasmas—or viruses are among the most vexing maladies that we deal with as arborists. Let's take a look at why this is the case. First, of what do we speak?

Dutch elm disease. Verticillium wilt on maple, and smoketree, and tuliptree, and many other hosts. Oak wilt. Fireblight on pear, mountain ash, and other members of the rose family (Rosaceae). Plum black knot on plums, cherries, peaches, almonds, and their ornamental cousins. Pine wilt disease. Phytophthora root and crown rot of beech and other hosts. Apple scab on crabapple. Tar spot of maple. Anthracnose on sycamore and anthracnose on dogwood and anthracnose on oak. Bacterial leaf scorch. Sudden oak death. Thousand cankers disease. Powdery mildews on many different trees.

What do all of the above have in common? They are all infectious tree diseases. Some are vascular diseases (destructive because the pathogen moves throughout the plant in the vascular = conducting system), such as Dutch elm disease, Verticillium wilt, and oak wilt. Some are leaf diseases such as apple scab or leaf and twig diseases such as anthracnose diseases. Some are worse than others, such as dogwood anthracnose, which is more severe than oak anthracnose.

Some are caused by pathogens with narrow host ranges, such as *Dibotryon morbosum* that causes plum black knot only on the genus *Prunus*. Some pathogens have wide plant host ranges, such as the *Verticillium* fungus with scores of susceptible tree host genera. Some of the pathogens infect through roots, such as the *Verticillium* fungus, others through stem and leaf tissue, such as the anthracnose fungi.

Some pathogens are moved from tree to tree through insect vectors, such as the *Ophiostoma ulmi* fungal pathogen that causes Dutch elm disease, vectored by elm bark beetles. Most infectious diseases are caused by fungi, while others are caused by bacteria (e.g. fireblight) and nematodes, such as pine wilt disease caused by pine wood nematode. Some diseases such as Dutch elm disease are devastating to plant health, while others cause mostly ornamental damage such as powdery mildews and tar spot of maple.

All these plant diseases are fascinating and important to arboricultural professionals. There are features of plant diseases, though, which confound and frustrate not only professionals but also our customers and clientele. Which brings us to the question…

Why Are Infectious Plant Diseases So Difficult to Manage?

Let us count just a few of the ways…

Inoculum is microscopic
Inoculation, infection, symptoms are separated in time
Disease control is largely preventative, not reactive
Weather is unpredictable
Pathogens change
There are so many host plants

Inoculum is microscopic

In their excellent book, *Essential Plant Pathology*, Gail Schumann and Cleora D'Arcy define inoculum as "the structure or part of the pathogen that initiates disease." Inoculum can be microscopic spores or threadlike mycelia of fungi, microscopic bacterial cells, microscopic parasitic eelworms known as plant parasitic nematodes, or submicroscopic particles of viruses or phytoplasmas, so small even regular light microscopes cannot detect this inoculum.

One of the reasons that infectious plant diseases were mysterious for so long—and why disease management is complicated—is that the inoculum of the pathogen is invisible to the naked eye when it arrives at the plant, penetrates plant tissue, and infects it. To use a non-tree example, when late blight of potato threatened crops and helped lead to the Irish Potato Famine, the *Gardener's Chronicle* opined:

"It was suggested that the rot might be caused by static electricity—generated in the atmosphere by the issuing puffs of smoke and steam from the hundreds of railway locomotives that had recently come into use, and for all that was surely known it might equally well be due, as others supposed, to mortiferous vapours or 'miasmas' rising from blind volcanoes in the interior of the earth."

We know better now. We have a germ theory of disease. But let's not be too proud of our superior knowledge: the invisibility to the naked eye of pathogens when they arrive, penetrate, and cause infections on plants still boggles the minds of many, if not most of us. We consider insects and mites to be small and hard to see, but they are gargantuan compared to "virulent plant pathogens" that cause infectious plant disease—along with the other two components of the disease triangle—"the susceptible host" and the "environment conducive to disease."

Inoculation, infection, symptoms separated in time

So, the inoculum that arrives at the plant via winds, splashing rain, or a vector cannot be seen. Then a spore germinates and penetrates into plant tissue, or a nematode inserts its stylus into the plant, or a vector inserts the pathogen into plant tissue—you still cannot see the pathogen. The pathogen then spreads through the plant and establishes a host-parasite relationship with plant cells.

You still cannot see the pathogen. In fact, you have no idea until symptoms develop on the plant, e.g. leaf blighting and discoloration along the veins of a sycamore due to an infection from the sycamore anthracnose pathogen. Symptoms develop days, usually a week or more, and sometimes months or years after inoculation, penetration, and infection. As tree care professionals we are effectively in the dark all that time. Amongst other things, this makes effective timing and use of disease-controlling pesticides such as fungicides difficult. Symptom development and damage to the plant may be inevitable, even when the infected plant looks fine.

Disease control is preventative, not reactive

So, we do not exactly live in a cloud of ignorance, in a world of "blind volcanoes" and "mortiferous vapours." Nevertheless, since we cannot see inoculation and infections occur, we must act proactively with regard to plant diseases. This means that in many cases, and for the most part (though there are systemic fungicides that help in some cases), we need to use preventive fungicide applications to prevent that germinated fungal spore from getting into plant tissue in the first place.

Better yet, and more sustainably, we need to employ our knowledge of genetic disease resistance and plant health and plant stress management to optimal effect. We need to recognize that 'Sargent' and 'Adirondack' crabapple have excellent resistance to apple scab, compared to 'Thunderchild' and 'Hopa'. If we know that we have a site with the *Verticillium* fungus well-established in the soil, which we can know from previous Verticillium wilt diagnoses, then do not plant highly *Verticillium*-susceptible species, such as Japanese maples (*Acer palmatum*), into that site.

Selecting the right plant for the right site ("which plants matter") is the greatest preventive maintenance practice we can use, not only for infectious disease management, but also for overall plant health. Eastern redbuds that are planted in open sun in unirrigated sites are more likely to become moisture-stressed and are more likely to have Verticillium wilt problems as well as Botryosphaeria canker disease—the two most common infectious disease problems of Eastern redbuds that cause stem dieback and eventual plant death. Prevent from the very beginning by not planting redbuds in those sites.

<u>Weather is unpredictable</u>

The environmental component of the disease triangle is crucial for plant diseases. Plant pathologists talk about infection periods for specific plant diseases, and the occurrence of these infection periods depends upon such things as the number of hours of leaf wetness and relative humidity. Of course this, in turn, is influenced by temperature. All of this plays into the overall weather, and we know how good we are at predicting the weather, even short term, much less long-term, as in over an entire growing season.

Temperature and moisture, for example, play a big role in the development of fireblight disease. Bad years for fireblight on Callery pear or crabapple usually relate to how warm and wet it is during bloom. The years in which there are massive blossom infections (greatest occurrence during wet weather during extended periods over 62 degrees) are years in which fireblight is worse. So it depends on whether these conditions occurred during the bloom of a particular Callery pear or crabapple in a particular part of the state or region.

Anthracnose diseases on oak, sycamore, and ash depend greatly upon cool, wet conditions during leaf emergence on these trees. Oak anthracnose is really noticeable on the lower canopy (less air movement) only once in a while—the years in which that oak (mostly in the white oak group) have leaves emerging during extended cool, wet weather. Bad years for rose black spot depend upon the number of times there are a certain number of hours of leaf wetness (exact number of hours needed depends upon the temperature variable) for the pathogen spores to germinate.

For the most part, we cannot use phonological calendars for infectious tree diseases. Using phenology (the relationship of environmental factors, such as temperature, to physiological events, such as flowering of plants or emergence and development of insects) for insect control timing is fairly straightforward, since it involves simply the temperature variable (heat units and degree days). With plant diseases, it is more complex because of the role of moisture in addition to temperature.

<u>Pathogens change</u>

'Indian Magic' has excellent scab resistance! Does not! Does too—I have an old report to prove it! Did once—but no longer! The reality is that we all are proud when we notice genetic resistance in plants to infectious diseases. In fact, sometime we go to considerable lengths and time with plant breeding to develop plants to provide both desired arboricultural characteristics and resistance to certain diseases. However, we have to remember that Nature is at it 24/7 in its own breeding experiments. Over time pathogens mutate, overcome resistance, and parasitize plants that once truly had good genetic resistance relative to a particular disease. Such is life in the jungle. Disease resistance is not necessarily forever, so we have to keep studying, learning, and adapting.

<u>There are so many host plants</u>

Physicians have so many advantages over plant doctors, though we at least do not have to deal with mole removal, skin diseases, brain surgery, or the pressure of our patients dying a human death. Physicians, however, have patients who talk—though so often we lie. Physicians also have the advantage of dealing with only one host—*Homo sapiens.* As we know, even dealing with the diseases and disorders of just one species—humans—can be anything but simple. As tree doctors, we deal with hundreds of different host plants, different species of maples (*Acer*) and oaks (*Quercus*), and different genera from *Acer* to *Zelkova,* from *Quercus* to *Xanthophyllum*.

Each of these plants has their own set of diseases and other problems. Remember that the multiplicity of host plants creates an extra layer of information for us to keep track of: apple scab does not occur on roses, Dutch elm disease does not occur on oak, black knot does not occur on pears, sycamore anthracnose does not occur on oak. Each host has its own set of horticultural best practices, but also its own set of disease weaknesses.

Infectious plant diseases are indeed a wonder. Pathological puzzlers provide a never-ending quest (don't even pretend to be a know-it-all) and plenty to wonder about.

As Shakespeare noted:

In Nature's infinite book of secrecy
A little I can read