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Are We Propagating Plant Diseases?

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Summary

In this presentation the author discusses examples of a few of the currently notable diseases caused by each of the major groups of pathogens (fungi, oomycetes, bacteria, viruses and nematodes). In the process, the author touches on boxwood blight, downy mildews, rose rosette and other diseases caused by emaraviruses, phytoplasmas, beech leaf disease, and the new vascular streak dieback disease.

INTRODUCTION

What the nursery industry does best is propagation. Over and over again, they start with a bagful of cuttings or a packet of seeds and transform them into a hoop house or a field of saleable plants, making much from a little.

The supervised growth that plants get during their time in the nursery allows a strong start for future landscape plants, attending to their needs for substrate, water and fertilization.

Exclude Pathogens from Propagation

But one of the secrets to success during propagation is keeping the pathogens (disease causing micro-organisms) out of the system. Their impact is greatest when they are there from the start. Pathogens are intimately related to the plants they parasitize and often hitchhike on them without causing obvious symptoms. Bringing many closely related plants into one tightly-spaced growing area sets up the very monocultures that we chide landscape architects for promoting. Optimal conditions for the plants are often also optimal for the pathogens — so, yes, we are often inadvertently propagating the pathogens along with the plants. The best nurseries struggle to perfect their plant and substrate choices, their irrigation methods, their fertility and their sanitation practices in order to grow the crops without favoring the pathogens.

The plant propagation phase is one of the most critical to manage, because plants are close together and irrigation is almost exclusively from overhead. Keeping the pathogens out of the propagation phase of production is critical for maximizing crop quality and minimizing disease management actions later on. The less the grower propagates plant diseases, the more successful the crops will be. Here are some general principles to follow:

- Exclude the pathogen. Be very fussy about the quality of plant material you bring into the nursery and practice careful sanitation. Reusing containers without first disinfesting them will lead to pathogens cycling through the nursery year after year.
- If you have your own stock plants, give them special care and be sure to leave field soil in the field as much as possible: take cuttings high on the plants and avoid the lowest mud-splashed branches. Bringing in cuttings from other nurseries means trusting the other establishments to have high sanitation standards and careful disease management. Cultivate relationships with reliable suppliers, rewarding them with your business.
- In a few specialized cases paying for treated seed may be worthwhile, or even treating it yourself. If you are an herb grower, for example, having your basil seed steam treated will lower the risk of early-season downy mildew losses. If you produce ornamental cabbages and kale, a hot-water treatment of seed done on premises can spare you losses from black rot, which is a bacterial disease caused by the bacterium *Xanthomonas campestris* pv. *campestris*.
- Train workers to inspect all plant material prior to and during sticking, discarding the obviously diseased propagules and perhaps sending samples off to a diagnostic lab. Roguing out the diseased cuttings can reduce future headaches considerably (**Fig. 1**). Keep scouting for disease and insect or mite problems throughout production.

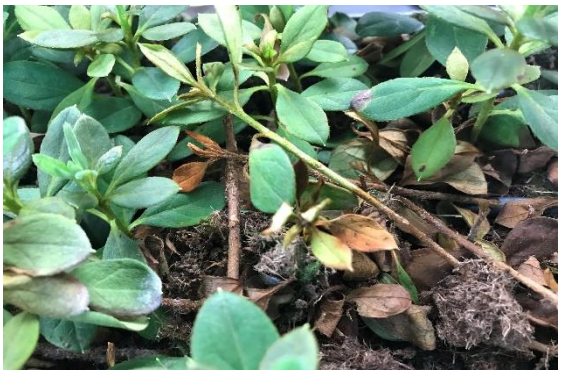

Figure 1. Symptoms of wilting and cankering caused by the fungus *Cylindrocladium scoparium* on rooted cuttings of azalea.

In this presentation we will discuss examples of a few of the currently notable diseases caused by each of the major groups of pathogens (fungi, oomycetes, bacteria, viruses and nematodes).

We'll touch on boxwood blight, downy mildews, rose rosette and other diseases caused by emaraviruses, bacteria (*Xanthomonas* spp.) on asclepias and geranium, phytoplasmas on spirea and echinacea, beech leaf disease, and the new vascular streak dieback disease.

Fungi

Boxwood blight. The boxwood blight disease has been in North American since 2011, but it was known in Europe since 1994 (Daughtrey, 2019). One fungus, *Calonectria pseudonaviculata*, causes the disease in the U.S.A. and Canada, but a second closely-related fungus, *C. henricotiae*, is found in a handful of European countries. It is to our advantage to avoid importing *C. henricotiae*, because it has less sensitivity to some of the fungicides used to manage boxwood blight and also has greater heat tolerance. Shrubs, hedges and topiary are all vulnerable, but the low hedges of an herb garden are especially likely to become infected. A consortium of researchers and industry advisors called BBIG, the Boxwood Blight Insight Group, was formed around an SCRI grant a few years ago; members collaborate with scientists around the world as well as with the boxwood industry and AmericanHort. The Horticultural Research Institute, HRI, manages the BBIG website, www.boxwoodhealth.org, where information and educational presentations, publications and illustrations are stockpiled for everyone's use. Quarterly international seminars are developed and the talks are stored at the website.

Boxwood blight causes tan leaf spots with diffuse black borders, tiny black shoot cankers, and defoliation (**Fig. 2**).

Figure 2. Black cankers and leaf blight caused by *Calonectria pseudonaviculata* on *Buxus sempervirens*.

Pachysandra and sarcococca are also hosts. Periodic fungicide applications and pruning out diseased areas allow maintenance of valuable boxwood plantings under Long Island weather conditions. Most commonly the contact fungicides chlorothalonil or mancozeb and the systemic fungicide propiconazole are used to keep boxwood healthy. Genetic resistance is being used where available in the trade and new plants are under development. New blight-resistant plants from the NewGen series ('Freedom' and 'Independence') are performing well against boxwood blight in university trials and also have boxwood leafminer resistance. A plant breeding effort in Belgium has led to the BetterBoxwood series that should be available in 2023. Symptoms have been determined to develop most easily at 77°F for *Buxus sempervirens* (American boxwood) and *B. sempervirens* 'Suffruticosa' (English boxwood), both highly susceptible. Recently it was reported that for the usually resistant cultivar 'Winter Gem' (Japanese boxwood), temperatures of 59°F markedly increase disease susceptibility (Weiland et

al., 2022). Going forward, the research community should investigate how individual cultivars of boxwood interact with *C. pseudonaviculata* and other important fungal pathogen(s) so that boxwood cultivar recommendations may made appropriate for each region of the country.

Oomycetes

Downy mildews. Fortunately, not every crop is plagued by a downy mildew. Some perennials are notorious for them (for example, geum, veronica, phlox, rudbeckia) and a few woodies (notably roses and viburnums) as well. Rudbeckias have had the greatest problems in recent years, showing downy mildew symptoms of purpling or yellowing on the upper side of leaves, and white sporulation on the undersurface of infected leaves (**Fig. 3**).

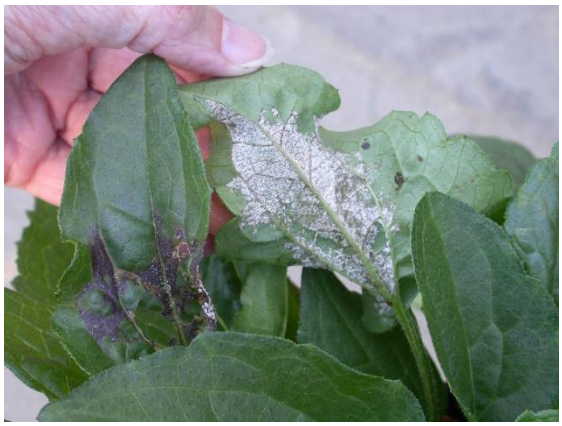

Figure 3. Purpling on the upper leaf surface and white sporulation of downy mildew on rudbeckia.

Among annuals, the most common hosts of diseases in this group are impatiens, sunflowers, coleus and pansy. The Beacon and Imara XDR series of impatiens have been developed by Ball and Syngenta, respectively, to answer the huge economic threat posed by the downy mildew of impatiens that became widespread beginning in 2011. These plants are highly resistant, but not entirely immune (Daughtrey et al., 2021), so they should be grown away from any susceptible impatiens or else protected with fungicides during production. Impatiens resistant to downy mildew are also being developed by Dr. Mark Bridgen at Cornell's LIHREC. A broad basis of resistance is desirable so that the pathogen (*Plasmopara destructor*) will not be easily able to adapt to the improved plants.

Phytophthora. Different species of *Phytophthora* are problematic on many nursery crops, especially those in the Ericaceae. Pieris, azalea, rhododendron and *Hedera* are some of the common hosts (**Fig. 4**).

Figure 4. Browning foliage and dieback are typical symptoms of *Phytophthora* blight during ivy propagation.

A recent addition to the list is *Phytophthora chrysanthemi*, first described from Ohio only 5 years ago (Lin et al. 2017). This pathogen is favored by high temperature conditions (30°C and above) and infection results in stunting, purpling and death of foliage, often seen on only part of a plant. ImmunoStrip® tests for *Phytophthora* (Agdia, Inc., Elkhart, Indiana) can be used to get an initial indication that this pathogen (rather than *Pythium* or *Fusarium* spp. or a bacterial infection) is responsible for symptoms in production or landscape, and then a diagnostic lab can confirm with culturing at 30°C.

Viruses

Emaraviruses. A new genus of viruses known as Emaraviruses was established in 2012, with the name coming from one of its members, European Mountain Ash Ringspot-associated Virus (EMARaV) (Mielke-Ehrel and Muhlbach 2012). The disease caused by an emaravirus that is best known to growers of ornamentals is rose rosette caused by Rose rosette virus (RRV) (Windham et al. 2019). There are a few other diseases in this grouping, including fig mosaic and raspberry leaf blotch, but more remain to be discovered. One has been reported from spicebush, *Lindera benzoin*, causing chlorosis (Mollov et al. 2019), and we have recently seen ringspot symptoms on Norway maple that we suspect might be an emaravirus. One trait that a number of the viruses in this genus have in common is that they are spread by tiny eriophyid mites. This is true for Rose rosette virus, spread by the mite *Phyllocoptes fructiphilus*. Symptoms on roses include reddened shoots, hyper-thorniness, witches'-brooms, and decline and death (Windham et al. 2019). Note that rose rosette affects multiflora rose (**Fig. 5**) as well as desirable crops including Knockout ® Rose. Either eliminate these plants from hedgerows around the nursery or else scout them for disease symptoms in the same way that you scout your rose crops. Discarding diseased specimens is the only control, so careful monitoring is important.

Figure 5. A multiflora rose with tiny strap-shaped leaves found adjacent to a nursery with rose rosette in their container rose crop.

Bacteria

Xanthomonas. Various bacterial diseases caused by species in the genus *Xanthomonas* are occasional problem in the nursery industry. Virginia and Ohio have both reported a *Xanthomonas* leaf spot on peony since 2009, and we have also seen this several times in New York (Oliver et al. 2012; Klass et al. 2019). With overhead watering, plants will show reddish purple-rimmed spots on leaves and stems. Early detection is important, because discarding infested plants is the best policy. Treatments such as copper and *Bacillus subtilis* materials are not strongly effective.

Xanthomonas hortorum pv. *hederae* is commonly found on English ivy and other ivies but is frequently confused with the common anthracnose (caused by a fungus, a *Colletotrichum* species). Copper materials will help to reduce both problems while you are seeking a proper diagnosis from a laboratory.

Black rot on ornamental cabbage and kale (*Xanthomonas campestris* pv. *campestris*) is the same disease fought by farmers working with food crops. The most common symptom is Vee-shaped chlorotic wedges showing black veins, which eventually turn necrotic. Seed transmission makes this disease far too common (Daughtrey 2021). Growing plants under a greenhouse roof is ideal to eliminate rainfall and rain splash effects but irrigate early in the day so that the foliage does not sit wet for long periods and scout to eliminate symptomatic plants that could be a source of infection for others. Hot water seed treatments have been developed for cabbage and kale crops but could be more difficult to achieve safely in seeds of ornamental crops: research is needed.

Geranium sanguineum and some other hardy geranium species can be a source of Xanthomonas bacterial blight for greenhouse *Pelargonium* crops, which are highly susceptible to *Xanthomonas hortorum* pv. *pelargonii*. This spring problems with infected cuttings brought in from offshore led to widespread greenhouse geranium losses of zonal and ivy geraniums. This re-emerging of a familiar disease represents a breach in the otherwise effective clean stock procedures which were set up by the international geranium industry to avoid shipment of *Ralstonia solanacearum* Race 3, Biovar 2, a Select Agent, into the United States. Prioritization of sanitation procedures is needed for this important crop. Clean stock programs must be followed to the letter because breaches in plant health security at the top can cause huge losses down the production chain. Agdia ImmunosStrip® tests (Agdia Inc., Elkhart, IN) were helpful this season for quickly identifying the diseased plants. Symptoms begin as small round spots or necrotic wedges at the edge of leaves but will progress to plant death under warm-temperature conditions (Nameth et al. 1999).

Milkweeds are susceptible to a wilt disease caused by a *Xanthomonas* (*Xanthomonas campestris* pv. *asclepiadis*) (**Fig. 6**).

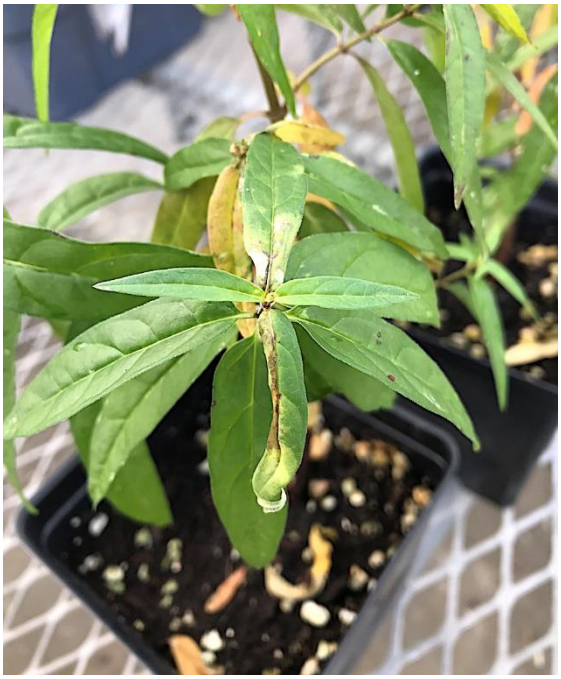

Figure 6. Milkweed with foliar blight after inoculation with the bacterium *Xanthomonas campestris* pv. *asclepiadis*.

Flynn and Vidaver (1995) reported susceptibility of *Asclepias syriaca*, *A. speciosa*, *A. tuberosa*, and *A. erosa*, plus a hybrid of *A syriaca* and *A. speciosa*, but not *A. subulata*; symptoms have been noted in swamp milkweed (*A. incarnata*) in our diagnostic laboratory as well. Procedures for seed treatment have not been worked out for this crop, but symptoms are serious and the disease is very contagious.

Phytoplasmas

The most familiar host of the aster yellows phytoplasma (a phytoplasma is a phloem-dwelling bacterium) is echinacea (**Fig. 7**), although it is possible to see this pathogen

affecting other plants in the Asteraceae as well.

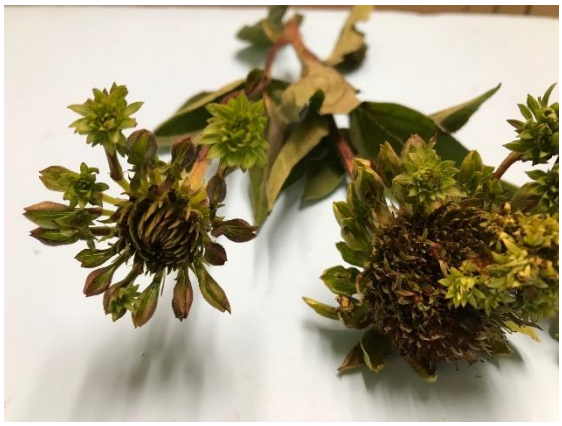

Figure 7. *Echinacea* with flower deformation due to infection by the aster yellows phytoplasma.

Typically, the aster yellows phytoplasma, vectored by the aster leaf hopper, will cause stunting, yellowing and peculiar-looking flowers. Both phyllody (conversion of flower parts to leafy tissue) and virescence (greening of flower petals) can occur on aster family members (e.g., marigold, coreopsis and China aster) with aster yellows. Echinacea develops especially dramatic symptoms, and also may show a similar but less dramatic look when infested by a tiny eriophyid mite called the coneflower rosette mite. A diagnostic test for the presence of the phytoplasma may be needed to tell which agent is operating on the plants. Scouting for both of these problems on echinacea and removing them when they are found is the appropriate initial response.

Spiraea spp. are subject to two viruses, Spiraea leaf spot virus and Spiraea yellow leafspot virus. Neither of these was found to be responsible for the plant stunting, shoot proliferation (witches'-brooms) and tiny leaves that were noted in Minnesota a decade ago (Lockhart et al. 2012)—these severe symptoms were instead determined to be due to a phytoplasma (**Fig. 8**). Spirea infection by a phytoplasma had been noted earlier in New York (Griffiths et al. 1994) and this same organism was detected in Minnesota in ornamental *S. japonica* and *S.* × *bumalda* This spirea stunt phytoplasma disease is not uncommon but it generally goes undiagnosed and unreported. Good performance of spirea in plantings will require that this disease no longer be propagated in the trade.

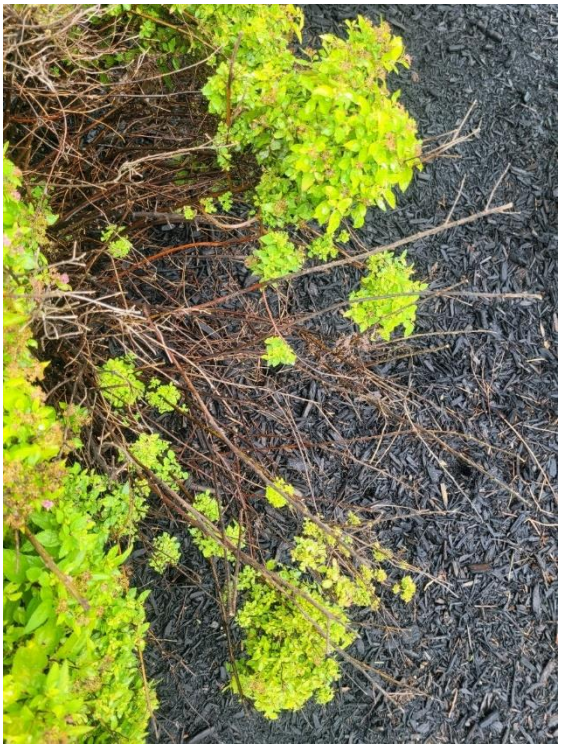

Figure 8. Spirea in the landscape with tiny leaves, witches'-brooming and dieback caused by the spirea stunt phytoplasma.

Nematodes

Beech leaf disease. Beech leaf disease is a new problem caused by an invasive exotic nematode. Symptoms were first noted in Lake County, Ohio, in 2012 but it was not until 2017 that a paper was published showing the link between the symptoms and the presence of a new subspecies of nematode, *Litylenchus crenatae* ssp. *mccannii*. Nursery trade has been one of the inadvert-

ent means of disease spread because symptoms on infested plants are easily overlooked; no vector has yet been identified but new counties and new states in its range are being detected every year. The nematode overwinters in buds and feeds on immature leaves before the buds unfold in the spring. In addition to shallow elongated leaf galls between veins, stunted and distorted leaves and bud death are characteristic of the disease and trees eventually are killed (**Figs. 9A and 9B**). Both the native American beech, *Fagus grandifolia* and the European beech, *F. sylvatica*, are susceptible to the disease. Effective treatments are being sought.

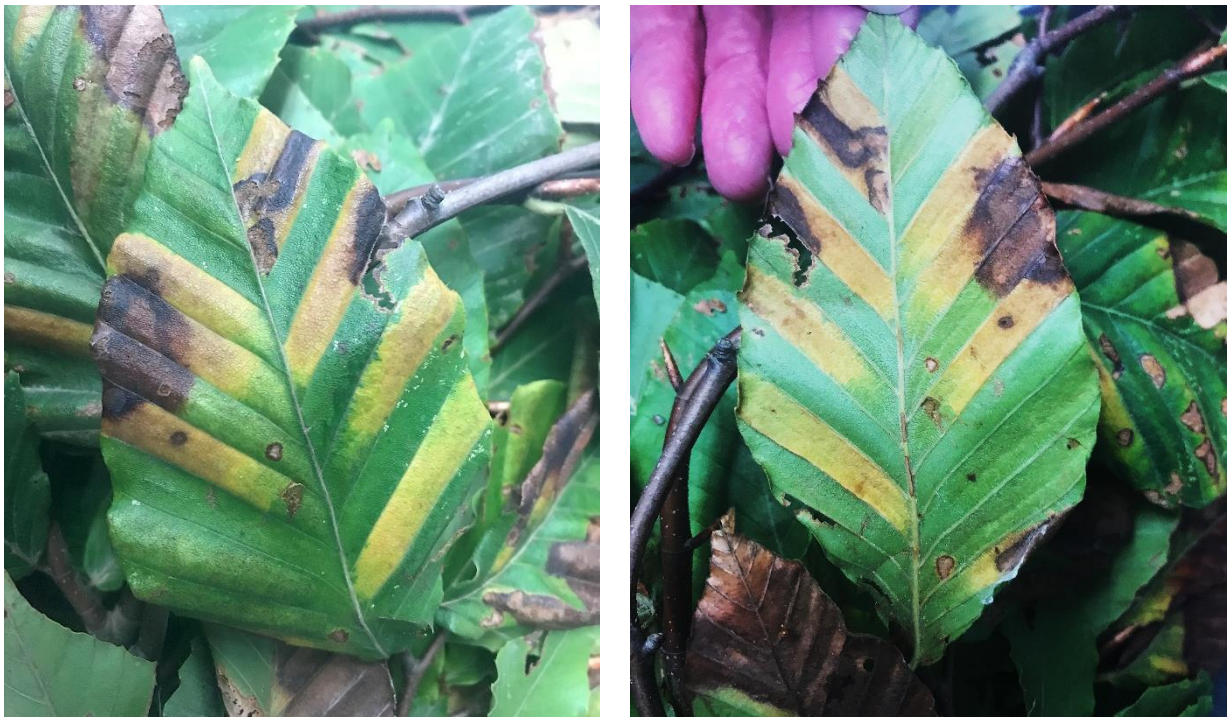

Figure 9. Leaf symptoms of Beech Leaf Disease, caused by the nematode *Litylenchus crenatae* ssp. *mccannii*. A) interveinal bands (leaf galls) seen from above B) view of lower leaf surface of same leaf.

Cause Unknown

Redbud vascular streak dieback. This disease appears to be new, but is it just becoming more noticeable because of stresses associated with global warming or changes in nursery practices (Beckerman et al. 2022)? The disease is causing concern in the southeast/mid-Atlantic area where much of the nursery stock for the Northeast comes from. No plant pathologist has yet demonstrated a definite cause-and-effect for a pathogen (through a process called demonstration of Koch's postulates) but evidence has mounted suggesting that the pathogen is *Rhizoctonia theobromae*. The fungus was previously considered a species of *Ceratobasidium*, *Oncobasidium* or *Thanetephorus*, and is listed as causing dieback in Asia and Australasia on cacao and avocado.

Within the nursery trade there have been reports of yellowing, stunting and severe dieback on redbud (Dismukes, 2022). Epicormic shoots (water sprouts) may form below the dieback, or the dieback may proceed down a branch into the main trunk and lead to death of the tree. The xylem of affected branches may show a dark streaking.

Plants from young to old are affected, in container and field production and in the landscape. Although the streaking suggests Verticillium wilt, no one has isolated a *Verticillium* species from the infected branches. A *Rhizoctonia* is isolated frequently, but this fungus might turn out to be an endophyte (just dwelling within the plant) rather than a pathogen. This pathogen suspect is reportedly difficult to culture and work with.

From the nursery perspective, it is important to avoid symptomatic material when grafting redbuds and to sanitize after each cut when pruning. There are no chemical control recommendations at this time but avoiding stresses such as flooding or growing at too low a pH is important for keeping stress out of redbud culture. Similar symptoms of vascular streaking have also been noted in calycanthus, dogwood, magnolia, red maple, spicebush and wax myrtle.

LITERATURE CITED

Beckerman, J., Creswell, T, Bonkowski, J. and Baysal-Gurel, F. (2022). Vascular Streak Dieback of Redbud: What Plant Pathologists Know So Far. Purdue University Landscape Report 22-11. https://irp.cdn-website.com/5d757b5b/files/uploaded/Redbud%20Vascular%20Streak%20Disease.pdf

Daughtrey, M., Beckerman, J., Davis, W.J., Rane, K., and Crouch, J.A. (2020). Corroboration that highly resistant impatiens cultivars are not immune to downy mildew diseases: a report of crop losses from two California producers. Plant Health Progress *21*:214-216. https://doi.org/10.1094/PHP-05-20-0040-SC

Daughtrey, M.L. (2019). Boxwood blight: Threat to ornamentals. Annu. Rev. Phytopathol. *57*:189-209.

Daughtrey, M. (2021). Examining Xanthomonas. GrowerTalks February. https://www.growertalks.com/Article/?articleid=25076

Dismukes, A. (2022). Vascular Streak Dieback in Redbud. TSU Nursery News to Use. Issue 33, March 8, 2022. https://www.tnstate.edu/agriculture/nrc/documents/NEWS2USE%20March%202022.pdf

Flynn, P., and Vidaver, A. (1995). *Xanthomonas campestris* pv. *asclepiadis*, pv. nov., causative agent of bacterial blight of milkweed (*Asclepias* sp.). Plant Dis. *79*:1176-1180.

Griffiths, H.M., Sinclair, W.A., Davis, R.E., Lee, I.M., Dally, E.L., Guo, Y.-H., Chen, T.A., and Hibben, C.R. (1994). Characterization of mycoplasmalike organisms from *Fraxinus*, *Syringa*, and associated plants from geographically diverse sites. Phytopathology *84*:119-126.

Klass, T.L., Long, J.J., Summers, J.A., Roman-Reyna, V., Koebnik, R., Jacobs, J.M. and Peduto-Hand, F. (2019). First report of bacterial blight of peony caused by *Xanthomonas hortorum* in Ohio. Plant Dis. *103(11)*:2940. doi.org/10.1094/PDIS-05-19-1123-PDN

Lin, S., Martin, D.E., Taylor, N.J., Gabriel, C. K. and Peduto Hand, F. (2017). Occurrence of *Phytophthora chrysanthemi* causing root and stem rot on garden mums in the United States. Plant Dis.*101(6)*. https://doi.org/10.1094/PDIS-12-16-1714-PDN

Lockhart, B., Mollov, D. and Voth-Hulshout, J. (2012). Association of spirea stunt phytoplasma with a disease of *Spiraea* spp. in Minnesota. Plant Health Progress. doi: 10.1094.PHP-2012-1023-01-BR/

Mielke-Ehrel, N., and Muhlbach, H-P. (2012). Emaravirus: A novel genus of multipartite, negative strand RNA plant viruses. Viruses MDPI *4(9)*: 1515-1536.

Mollov, D., Grinstead, S., Fuentes-Bueno, I., Creswell, T., Ruhl, G., Bush, E., Hansen, M.A., Beale, J. and Johnson, D. (2019). New emaravirus identified in spicebush (*Lindera benzoin*). https://www.ars.usda.gov/research/publications/publication/?seqNo115=360928

Nameth, S.T., Daughtrey, M.L., Moorman, G.W., and Sulzinski, M.A. (1999). Bacterial blight of geraniums: a history of diagnostic challenges. Plant Dis. *83(3)*:204-212.

Oliver, C.L., Cai, R., Vinatzer, B.A., Bush, E.A., and Hansen, M.A. (2012). First report of bacterial spot of peony caused by a Xanthomonas sp. in the United States. Plant Dis. *96(4)*:581. https://doi.org/10.1094/PDIS-11-11-0919

Weiland, J.E., Ohkura, M., Scagel, C.F., Davis, E.A. and Beck, B.R. (2022). Cool temperatures favor growth of Oregon isolates of *Calonectria pseudonaviculata* and increase severity of boxwood blight on two *Buxus* cultivars. Plant Dis.106:3100-30108. https://doi.org/10.1094/PDIS-04-22-0769-RE.

Windham, A., Windham, M. and Hale, F. (2019). Early detection of rose rosette disease. University of Tennessee Institute of Agriculture Fact Sheet. SP 806 03/19 19-0165 https://extension.tennessee.edu/publications/Documents/SP806.pdf