

Diseases of Urban Plants in Arizona



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This information has been received by university faculty.

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INTRODUCTION

Arizona is a large, square-shaped, climatically diverse state of approximately 114,000 square miles within the north latitude lines from 32 to 37 degrees. Geographically the state can be divided roughly into four areas; southwest, central, southeast, and northern. These areas, in general, correspond with four climatic zones. The zones include low desert areas (elevations below 1000 feet) that are found primarily in Yuma, Maricopa and Pinal counties where annual precipitation is low (less than 4 inches), frosts are rare, and high summer temperatures are typical (average daily high temperature during June, July, August, and September are above 100°F). Intermediate elevation areas (elevations from 1200 to 3300 feet) occur primarily in La Paz, Maricopa, Pima, Gila, and Pinal counties. These areas receive more rainfall (10 to 13 inches annually), occasional frosts and lower temperatures (there is approximately a 3°F drop in temperature for every 1000 foot increase in elevation). The high desert areas with elevations from approximately 3300 to 4500 feet, typically occurring in the counties of Yavapai, Santa Cruz, Cochise, Gila, Graham, and Greenlee, have higher rainfall (12 to 18 inches), 74 to 100 frosts per year, and colder temperatures. The northern counties of Arizona including Coconino, Navajo, Apache, and certain areas in Mohave, Yavapai, Gila, and Greenlee are, in general, higher in elevation with colder winter climates. The growing season in some of these locations averages only about 150 days a year.

A large and diverse number of plants are grown for landscaping purposes in Arizona. They include perennial and annual ornamentals, evergreen, and deciduous vines, deciduous and evergreen shrubs and trees, conifers, palms, bamboos, turf and other ground covers, citrus, fruit trees, and native plants.

Interestingly, in our desert environment many of the parasitic diseases in landscape plants are caused by a limited number of plant pathogens. Most of the important fungal plant pathogens survive in the soil and cause root, crown and wilt diseases of a large number of unrelated plants. These include *Phymatotrichopsis omnivora* (Cotton or Texas root rot), *Phytophthora* spp. (root and crown diseases), *Pythium* spp. (seedling and root diseases),

Rhizoctonia solani (seedling, root and stem diseases), and *Verticillium dahliae* (wilt diseases). Other soil fungi including *Fusarium* spp., *Thielaviopsis basicola*, and *Macrophomina phaseolina* are occasionally involved as root and crown pathogens of a number of landscape plants. However, they are insignificant when compared with the previously listed pathogens. They will not be discussed in this publication.

Fungi that cause foliage diseases in our dry environment are rare. Two groups, however, are important. They include the powdery mildew fungi (species of *Uncinula*, *Spaerotheca*, *Erysiphe*, *Microsphaera*, *Phyllactinia*, *Podosphaera*, *Oidiopsis* and *Oidium*) and the rust fungi, including species in several genera including *Phragmidium* and *Puccinia*. Other important plant pathogenic fungi, involved as causal agents of wood decay and canker diseases in woody perennials, include *Cytospora* sp. (*Cytospora* canker), *Hendersonula toruloidea* (sooty canker), and genera of wood rotting basidiomycetes such as *Ganoderma*.

Only a few bacterial plant diseases are of significant importance to discuss in detail. They include crown gall (*Agrobacterium tumefaciens*), oleander gall (*Pseudomonas syringae* pv. *savastanoi*), fire blight (*Erwinia amylovora*), bacterial necrosis of saguaro (*Erwinia* spp.) and wetwood or slime flux. Foliar diseases are rare and insignificant.

Virus diseases, although of great importance in vegetable crops, citrus, and certain ornamentals are less common and less important in urban plantings. Nematode and mistletoe diseases, because of their widespread occurrence, will be covered. The emphasis in this publication is to discuss primarily the major parasitic and nonparasitic diseases that affect the most important landscape plants grown in Arizona.

Parasitic diseases

FUNGI

PHYMATOTRICHOPSIS ROOT ROT

The most important disease of woody, dicotyledonous plants including perennial ornamentals, perennial vines and perennial shrubs and trees in Arizona is *Phymatotrichopsis* root rot (Cotton or Texas root rot) caused by a unique and widely distributed soil-borne fungus, *Phymatotrichopsis omnivora*.



Figure 1. Symptoms of *Phymatotrichopsis* root rot in peaches. Note the dead trees with attached foliage.

The fungus is indigenous to and occurs in the alkaline, low-organic matter soils of the southwestern United States and central and northern Mexico. Of the thousands of fungi that cause disease in plants, *P. omnivora* is unique in certain biological characteristics. The fungus has one of the largest host ranges of any known fungal pathogen. Over 2300 species of unrelated plants are susceptible to the disease. Isolates of the fungus are non-specific in their pathogenicity. For example, isolates that kill hundreds of deep rooted dicotyledonous, urban plants are also pathogenic to important crop plants in Arizona such as cotton, alfalfa, stone fruits, and grapes. Isolates from these crop plants are in turn pathogenic to urban plants. Thus, home sites established in old cotton or alfalfa fields, or other areas with a history of *Phymatotrichopsis* root rot can become disaster areas for urban landscapers.

The fungus has almost no method of dissemination but has the unusual capability of surviving in soil in the

absence of hosts for very long periods of time. The disease symptoms usually appear during the summer. The fungus only infects roots of mature plants. Seedlings are not susceptible to this disease.

Distribution of the Disease in Arizona— Heavily infested areas of *Phymatotrichopsis* root rot include the flood plains and certain tributaries of the Gila River (Safford, Duncan, Solomon, Thatcher, Fort Thomas, Pima, Eden, Florence, Sacaton, Buckeye, Gila Bend, Agua Caliente, Growler, Roll, Mohawk, and Dome Valley); the Santa Cruz River (Sahuarita, Tucson, Cortaro, Avra Valley, Rillito, Marana, Red Rock, and Eloy); the San Pedro River (Hereford, St. David, Benson, Pomerene, Redington, Mammoth, and Winkelman); Colorado River (Parker, Poston, Ehrenberg, Yuma, Somerton, and Gadsden) and certain locations of the Salt River and Queen Creek. Other infested areas include Chandler, Aguila, San Simon, Bowie, McNeal, Douglas, and Duncan.

The “mesa” (land at elevations above the influence of the Colorado River) in Yuma County seems to be free of the disease, whereas many “valley” sites are infested. *Phymatotrichopsis* root rot occurs at elevations as high as 4,700 feet in the Elgin and Sonoita areas of Santa Cruz County, in the Nogales area and Sierra Vista. Disease has never been detected in the Bonita area north of Willcox to Kansas Settlement, but in the Sulphur Springs Valley, the disease is found near Elfrida, McNeal, and Douglas.

The fungus is not uniformly distributed in local situations. Two distribution patterns are common. In one situation the fungus may occur in many small scattered circular areas, a “shot-gun” scenario.



Figure 2. A typical spore mat of *Phymatotrichopsis omnivora*. These fungal structures occur on the soil surface in shaded areas during the summer “monsoon” season.

In other situations the infested areas are large and few in number. This explains why the disease may occur in one small area of a landscape throughout the property.

Symptoms— Infected plants suddenly wilt during the summer when temperatures are high. Dead or dying foliage remains attached to the infected plant. The roots of the infected plants are rotted and brown in color.

Most of the plants discussed in this publication when



Figure 3. Strands of *Phymatotrichopsis omnivora* growing on the surface of an infected root.

planted into areas infested with *P. omnivora* show no symptoms during the first few years after planting. This is in contrast with certain tap rooted crop plants such as cotton and alfalfa that become infected and die the first summer after spring planting. The fungus is deep seated in the soil, and it may simply be that roots of many susceptible plants do not grow into the deeper, infested areas for a number of years. In grapes, for example, symptoms usually first appear two to four years after planting. Some trees show no symptoms for five or more years after planting. Symptom development and fungal activity is different in plantings in low elevations in Arizona as compared to plantings above 3,600 feet. Symptoms at low elevations consist primarily of initial stress, wilting of foliage and death of the entire plant within a few days after initial symptoms. This death usually occurs from late May through September. At higher elevations, plants may not wilt suddenly, but die more slowly.

Because plants may die during the summer for reasons other than *Phymatotrichopsis* root rot, it is necessary to examine root tissue for the presence of the fungus. The only positive proof of death caused by *P. omnivora* is to examine the cortical tissue of rotted, decayed roots and to identify the characteristic mycelial strands that are produced by the fungus.

This examination can be made by an experienced person with the use of a hand lens. However, these strands, masses of vegetative mycelial growth that are unique to this pathogen, can be more easily identified in the laboratory under a dissecting or compound microscope.

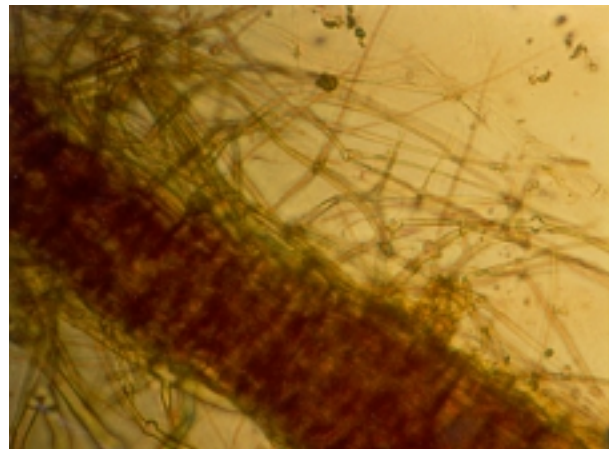


Figure 4. The appearance of the strand in Fig. 3 as seen under the compound microscope.

Phymatotrichopsis omnivora may produce fungal spore mats on the surface of soil during the monsoon rain period.

The spore mats are occasionally seen in shaded areas at the base of infected plants during hot, rainy periods in July and August. They are not seen at other times. The usual size of the spore mat is 4 to 8 inches in diameter and about 1/4 inch thick. The spore mats appear, almost mystically, overnight. The mats are initially white in color but become brownish in color after 2 or 3 days of growth. The powdery mass of spores produced on the surface of the mat are non-functional. They have never been germinated, and they seem to play no role in dissemination of the pathogen.

Biology of *P. omnivora*— The fungus appears to occur deep in the soil in localized patterns. *P. omnivora* has no effective method of dissemination since there are

no aerial or soil-borne spores that spread the fungus. The pathogen produces two important structures, sclerotia and strands. Sclerotia enable *P. omnivora* to survive in soil for many years. The sclerotia are small (up to 1/4 inch in diameter), roundish masses of hyphae. When mature, they have a thick outer rind. Sclerotia have been found in soil at depths up to 12 feet. Mycelial growth from germinating sclerotia initiate root infection. The fungus then produces interwoven masses of hyphae known as strands. The strands grow and colonize root tissue. Extensive root infection results in wilting and plant death. Strands, utilizing infected root tissue as an energy source, grow short distances through the soil to infect healthy roots.

Growth of strands from one host to another is probably the only available method of spread for the fungus and explains a typical pattern of kill in home landscaping situations where susceptible trees or shrubs are planted adjacent to each other. The fungus may kill one plant 2 or 3 years after the initial planting. Spread occurs in later years by strand growth from infected to healthy root tissue. Eventually, the entire group of plants may succumb to the disease.

It should be emphasized that the fungus is only a pathogen of mature roots of dicotyledonous plants. All monocotyledonous plants are immune to this disease. Winter annuals escape the disease because *P. omnivora* is not active in cold soils.

Control— A positive identification of the pathogen on roots is essential. In a disease situation not all roots are infected. Select roots with discolored, rotted outer bark. The diseased roots should be about 3/4 inch thick and 6 to 9 inches in length. Microscopic examination will reveal the unique strands of the fungus on the outer bark. Strands can be most easily identified on fresh material. However, they can also be seen on the surface of old, dead roots.

The only real effective method of control is to plant immune or highly resistant species in infested areas. Dicotyledonous plants grown as summer or winter annuals normally escape infection by *P. omnivora*. All monocotyledonous plants, either annuals or perennials, are immune to the disease. This includes large numbers of ornamentals in the Amaryllidaceae, Liliaceae, Iridaceae, Palmaceae, and the large grass family, Gramineae. Important immune plants from these plant families that are commonly grown in Arizona include palms in the genera *Washingtonia* (fan palms), *Phoenix* (date palms), and *Arecastrum* spp.

(Queen palms), *Agave* and *Yucca* spp., bamboos and many perennial ornamental grasses.

Other dicotyledonous desert plants, although not immune to the disease, are tolerant and usually grow normally in infested areas. They include species in the genus *Cercidium*, *C. floridum* (blue palo verde), *C. microphyllum* (foothills palo verde), *C. praecox* (Sonoran palo verde); the genus *Prosopis*, *P. velutina* (honey mesquite), *P. chilensis* (Chilean mesquite); *Simmondsia chinensis* (jojoba); *Parkinsonia aculeata* (Parkinsonia), *Condalia lycioides* (gray thorn) and *Chilopsis linearis* (desert willow). Other plants include *Amorpha fruticosa* (false indigo), *Celtis* spp. (hackberry), *A. greggi* (catclaw), *Larrea tridentata* (Creosote), *Fouquieria splendens* (ocotillo).

There are probably many other native plants in this category. As interest increases in the use of drought and heat tolerant native plants for landscaping purposes, our list of resistant plants may increase. We do know that some commonly planted non-native dicotyledonous trees and shrubs such as mulberry, Aleppo pine, and citrus are rarely affected by the disease. The list of susceptible plants is more reliable than plants in the resistant list. This, of course, is due to the fact that plants that succumb to the disease can be easily catalogued whereas plants that appear resistant may appear so simply because they have not been exposed to the pathogen. Susceptible plants grown in Arizona include: *Prunus* spp. including almonds, apricots, cherry, sweet cherry, sour cherry, nectarines, plums, peaches; *Fraxinus* spp. including Arizona ash (*F. velutina*); cottonwood, (*Populus deltoides*), *Ulmus* spp. including chinese elm (*U. parvifolia*) and siberian elm (*U. pumula*); *Ficus* spp. (figs); honey locust (*Gleditsia* spp.); magnolia (*Magnolia grandiflora*); pear (*Pyrus communis*); pecan (*Hicoria pecan*); pistachio (*Pistacia* spp.); pomegranate (*Punica granatum*); sycamore, american and london plane (*Platanus occidentalis* and *P. acerifolia*); chinaberry tree (*Melia azedarach*); willow, weeping and golden (*Salix babylonica* and *S. alba*), bottle tree (*Brachychiton populneum*), silk oak (*Grevillea robusta*); pepper tree, Brazilian and California (*Schinus terebinthifolia* and *S. molle*); Japanese privet (*Ligustrum japonicum*); African sumac (*Rhus lancea*), xylosma (*Xylosma congestum*), oleander (*Nerium oleander*), carob (*Ceratonia siliqua*) and Cassia. Other genera with susceptible species include: *Vitis* spp. (grape), *Ilex* spp. (holly), *Cotoneaster* spp. (cotoneaster), *Malus sylvestris* (apple), *Juglans* spp.

(walnut), *Buddleia* spp. (butterflybush), *Syringa* spp. (lilac), *Pittosporum* spp. (Pittosporum), *Wistaria* spp. (wisteria), *Rosa* spp. (roses), *Rubus* spp. (berries), and *Spiraea* spp. (spirea).

PHYTOPHTHORA DISEASES

The genus *Phytophthora* contains approximately 35 species of highly pathogenic and destructive plant pathogens. All species are pathogenic. They attack hundreds of species of higher plants throughout the world causing unusually diverse types of plant diseases including leaf and shoot blights, flower, fruit and bud rots, crown rots, stem and trunk cankers of woody and herbaceous plants, seedling damping-off, necrosis of feeder roots and collar and root rots.

In Arizona, because of our desert climate, fungus diseases that affect above ground plant parts (foliage, flowers, fruit, etc.) are rare. Thus, infections by species of *Phytophthora* most commonly occur below ground or at the soil line. Typically, these diseases include seedling damping-off, necrosis of feeder roots, rots of mature roots, and crown and collar rots of woody and herbaceous plants. The identification of a *Phytophthora* as the cause of a root or crown disease is difficult because below ground infections usually cause non-specific above ground symptoms. Also, the fungus is microscopic and difficult to isolate and identify from infected below ground tissues.

Most studies in Arizona concerning diseases caused by *Phytophthora* species have involved commercial crops and not plants used in urban situations. These diseases include root rot of alfalfa (*P. megasperma*), safflower (*P. drechsleri*), citrus (*P. parasitica* and *P. citrophthora*), root and crown rot of apple (*P. cactorum* and *P. cambivora*), crown, stem, and fruit rot of pepper (*P. capsici*), fruit rot of pumpkin (*P. capsici*) and boll rot of cotton (*P. capsici*). The last three diseases occur only during the summer rainy season at elevations above 4000 feet in southeast Arizona.

Several of these species have very wide host ranges. For example, *P. parasitica*, which is the major pathogen causing root disease in citrus grown in Arizona, causes root and crown diseases of the following commonly grown landscape plants in Arizona; *Grevillea robusta* (silk oak), *Leucophyllum frutescens* (Texas ranger), *Hibiscus* spp., *Petunia* spp., *Rosmarinus officinalis* (rosemary), *Simmondsia chinensis* (jojoba), *Verbena* spp., and *Vinca* spp. (periwinkle).

Other diseases in Arizona where a species of *Phytophthora* has been isolated include root and crown rot disease of *Matthiola* spp. (stock), *Antirrhinum majus* (snapdragon), *Aster* spp., *Lilium* spp. (lily), *Paeonia* spp. (peony), foliage plants including *Peperomia* spp., *Hedera* spp. (ivy), and *Dieffenbachia* spp. Other *Phytophthora* root and crown diseases occur in *Juglans* spp. (walnut), *Pinus* spp. (pines), *Prunus* spp. (peach, apricot, cherry), *Pyrus communis* (pear), *Quercus* spp. (oaks), *Salix* spp. (willows), *Ilex* spp. (holly), *Juniperus* spp. (junipers), *Cerotonia siliqua* (carob tree), *Bougainvillae* spp., and *Hicoria* (pecan). No foliar diseases caused by *Phytophthora* spp. have been described from landscape plants in Arizona. *Phytophthora* bud rot of palms, caused by *P. palmivora*, is a serious disease in the wet tropics. During our monsoon, rainy season this disease has been occasionally seen in Arizona.

Symptoms— A number of *Phytophthora* spp., including *P. parasitica* and *P. cactorum* infect roots and crown tissue of host plants ranging from herbaceous annuals to woody perennials. Symptoms, however, resulting from these infections are basically similar. As an example, symptoms of two diseases, *Phytophthora* crown and root rot of petunia (an herbaceous annual) caused by *P. parasitica* and collar rot of apple (a deciduous woody perennial) caused by *P. cactorum* have much in common. Symptoms, although obviously developing in different time frames, are similar and



Figure 5. A trunk canker caused by *Phytophthora parasitica* in citrus. Note the discolored lesion in the bark. The fungus can be isolated from the lesion.

consist of overall plant stress, stunting, change in leaf color, wilting, and eventual plant death.

Phytophthora parasitica infects the lower stem of petunia at or slightly below the soil line. The fungus grows into and kills stem tissue. Infected tissue rots and becomes dark in color.

As the disease progresses, the entire plant wilts and dies. The disease is most common in seedlings transplanted during hot weather in September and October. Optimum temperature for fungal activity is about 85 °F. Crown rot of apple has many similarities to this disease. The main pathogen, *P. cactorum*, infects the trunk at or below the soil line. Initially, during the summer, leaves of infected trees may appear light green to yellow in color. Fruit may be small and color prematurely. The tree may be stunted. The optimum time to survey for collar rot of apples is during September, October, and November. During this period, infected trees appear stressed with stunted and dead terminal growth. Leaves are reddish-yellow in appearance. A dark brown canker at or below the soil line is a characteristic symptom.



Figure 6. Crown rot of apple caused by *Phytophthora capsici*. Note that the canker is below the soil line.

If no cankers are found on trees, then factors other than *Phytophthora* are involved. Active cankers are moist in appearance. An exudate may occur at the margins of the canker. Infections are most common and canker development most active during cool-cold weather. This is because the optimum temperature for growth of *P. cactorum* is approximately 50 to 60 °F. Disease development is inhibited at soil temperatures above 80 °F.

The symptoms described for the petunia and apple diseases are essentially identical for the *Phytophthora* diseases that affect the other herbaceous and woody plants described in the previous section.

Biology—The basic biology of *Phytophthora* spp. that occur in Arizona is very similar. All species survive and live indefinitely in soil. Thick-walled, microscopic survival structures, oospores and chlamydospores, are produced in infected host tissue. There is variation between species as to the presence or absence of these spores and also to their size and shape. The most reliable method of identifying *Phytophthora* spp. is the finding of the sporangial stage. They are commonly produced on infected tissue and can be seen on microscopic examination of isolations made on specific media. Oospores and chlamydospores germinate under saturated soil conditions to produce characteristic, microscopic, lemon shaped sporangia. Each sporangium liberates swimming spores called zoospores. They swim through water and contact roots or the lower trunk tissue of potential hosts where they germinate and infect these tissues. The fungus grows into host tissue, girdling the infected root or trunk and eventually killing the tree. As the host dies the fungus produces the survival structures in decaying tissue. If the tree is removed these spores are returned via rotted host tissue to the soil where they enable the fungus to survive in the absence of a host. Few studies have been made on the natural occurrence of *Phytophthora* spp. in Arizona soils. However, studies in Arizona support the thesis that *Phytophthora* pathogens of urban plants are commonly introduced into Arizona on imported nursery stock.

Control Herbaceous Plants—The control of *Phytophthora* diseases in bedding plants and other herbaceous plants starts with the purchase of disease-free plants. For the homeowner this is sometimes difficult. Young seedlings, petunias, for example, may be infected but show no symptoms. The shock of transplanting, and overwatering coupled with high temperature triggers disease development. All *Phytophthora* diseases occur primarily in overwatered, heavy, poorly drained soils. Any technique that improves soil percolation is helpful in disease control. There are a number of fungicides available as drenches that are highly active against *Phytophthora* spp.

Woody plants— Avoid planting into heavy, poorly drained sites. Break open any caliche area that prevents water percolation. Avoid overwatering. Once collar rot has been identified there are few options available for control. A systemic fungicide is applied as a drench around the trunk of infected trees. Severely infected trees cannot be saved. The fungicide is effective in controlling the spread of the disease and also for treatment of early infections. Certain citrus are susceptible to *Phytophthora* foot and root rot and others are highly resistant. For example, susceptible varieties include lemons (*Citrus limon*), sweet orange (*C. sinensis*), limes (*C. aurantifolia*), grapefruit (*C. paradisi*), and Troyer and Carrizo citranges. Resistant citrus commonly planted in Arizona is sour orange (*C. aurantium*).



Figure 8.

PYTHIUM DISEASES

It is appropriate, for a number of reasons, to compare the genus *Pythium* with the previously described genus, *Phytophthora*. First, although the two genera are closely related, they differ in certain biological characteristics. For example, all described species in the genus *Phytophthora* are plant pathogens. The isolation of or even



Figure 10. *Pythium* blight in turf grass. Note the irregular, dead areas where the fungus is active.

observation of a species of *Phytophthora* in diseased plant tissue is sufficient evidence implicating the fungus as the cause of the disease.

Pythium spp., however are ubiquitous in soil and aquatic environments. Most of the 100 species described infect seeds, roots, or aerial parts of a wide range of plants.



Figure 9. These two postemergence seedling diseases (citrus, fig. 8 and beans, fig. 9) could be caused by infection with a number of soil occurring fungi including species in the genera *Pythium*, *Phytophthora* or *Rhizoctonia*.

Some species, however, do not cause disease and are saprophytic on decaying plant debris. Species of *Phytophthora* often invade woody, mature plant tissue. Pathogenic *Pythium* spp. invade and cause disease primarily in young meristematic, herbaceous tissue. Species in both genera survive indefinitely in the soil and, under desert conditions, cause diseases primarily of below ground tissues. *Phytophthora* spp. have limited soil saprophytic capabilities. They are slow growing and isolated with difficulty from infected tissue. Specialized, specific media are necessary for isolation. *Pythium* spp., in contrast, are easily isolated from infected host tissue on water agar or other simple media.

There is also, in general, less host specificity in *Pythium* than in *Phytophthora*. The two most important *Pythium* spp. in Arizona, *P. aphanidermatum* and *P. ultimum* are aggressive, rapidly growing soil saprophytes.

They readily colonize soil organic matter. Infection of below ground plant tissue occurs, as with species of *Phytophthora*, under saturated soil conditions. The two species differ primarily in their response to soil temperature. *Pythium ultimum* is pathogenic primarily in soils that are near or below 60°F whereas *P. aphanidermatum* has optimum temperature requirements for pathogenicity above 85°F.

Symptoms— *Pythium ultimum* and *P. aphanidermatum* are primarily involved in seedling diseases of bedding and ornamental plants. They are both indigenous in Arizona soils. Both species are known pathogens of a number of agricultural crops grown in Arizona including several vegetable and field crops. In landscape plants, however, these two species are important as causal organisms in seed decay, pre and post emergence damping off of seedlings and root rot of immature or herbaceous plants. Seeds or seedlings rot before or after their emergence from the soil. Post emergence damping off can occur several weeks after emergence. Seedlings become less susceptible with increasing age.

Pythium root rot is also a common disease in many foliage plants including *Philodendron*, *Peperomia*, *Scindapsus*, and *Syngonium*. A wide range of young greenhouse, bedding, and garden and landscape plants

are susceptible to *Pythium* root rot. For diagnosis, affected plants should be carefully removed from the soil and roots washed in water. Roots and lower stems are often brown or black.

The stem slightly above or below the soil line may be smaller in diameter at the infection site than healthy stem tissue. Damping off in flats of bedding plants often starts in the corner or center of the flat. The fungus, after introduction into pasteurized soil, spreads rapidly from diseased to healthy seedlings. Temperatures that adversely affect seed germination and seedling growth increase disease incidence. Wet and poorly drained soils also are factors in increased incidence of disease.

In greenhouse situations, *P. aphanidermatum* is a serious problem only when air and soil temperatures are above approximately 85°F. *Pythium ultimum*, is not pathogenic at these temperatures and becomes active in cold (below 65°F) wet soils.

Biology— Both species produce oospores. *Pythium aphanidermatum* produces sporangia and zoospores. *Pythium ultimum* produces sporangia. These sporangia, however, germinate with the production of mycelia and no zoospores are produced. They both have very wide host ranges and both are non-specific in their host specificity. In other words, an isolate of *P. aphanidermatum* that causes seedling disease in tomatoes will also cause disease in petunia seedlings. Because of the production of oospores both species survive indefinitely in soil.

Control— Garden crops that are seeded directly in the soil are best protected against seed and seedling disease by treating seeds with a fungicide. Most commercial seed bought by landscapers has been treated with fungicides. Any factor that aids in quick germination and rapid seedling growth reduces the chance of *Pythium* seedling diseases. These factors include proper planting period, careful preparation of the seed bed to increase drainage, no overwatering, use of high quality seed, and proper fertilization.

RHIZOCTONIA DISEASES

Although there are several species of *Rhizoctonia* described as plant pathogens, *R. solani*, is the most important species in the genus.

Rhizoctonia solani, a soil borne fungus, combines aggressive saprophytic activity with almost unlimited



Figure 7. Root lesions caused by *Rhizoctonia solani* (left) and *Pythium* spp. (right). Note the distinct, sunken, reddish lesion caused by *Rhizoctonia* in comparison with the overall, blackened root infected with *Pythium*.

pathogenic capabilities. The fungus is a worldwide pathogen of hundreds of unrelated plants grown in climates as diverse as our irrigated desert to the humid tropics. In Arizona, *R. solani* is an important pathogen of many of our agricultural crops including cotton, potatoes, lettuce and many other vegetables and field crops. The fungus causes, seed decay, pre and post emergence damping off of seedlings, bulb rots, root rots, crown blights, neck rots and lower stem rots. Almost any plant tissue in contact with the soil is susceptible to infection. Diseases of aerial plant tissue, including upper stems, leaves, flowers, and fruit, caused by *R. solani*, are common in humid areas but are rare in our desert environment. *Rhizoctonia solani* does not invade and cause disease, under our conditions, in woody plant tissue. Established woody plants including trees, shrubs and vines are not affected by *Rhizoctonia*. The fungus, as with *Pythium* spp., is a pathogen primarily of young, succulent, immature tissue.

Symptoms— During seedling germination and emergence, the fungus causes partial or complete girdling of emerged seedlings at or near the soil surface. The lesions on lower stems are sunken and dark in color. When the soil is moist the fungus grows as weblike mycelium on the soil surface and in the lesions. Mycelial growth is easily visible with a hand lens. Most infections of seedlings and cuttings occur at or just below the soil surface. Infected seedlings wilt and die. Cuttings never root, and they eventually collapse. In plants like dichondra (*Dichondra repens*), the fungus invades and causes brown lesions on the lower stems. The lesions are sunken and dark in color. Mycelial growth is evident in the infected areas. Similar infections occur in periwinkle (*Vinca major*) and foliage plants such as *Peperomia*. *Rhizoctonia solani* may blight a large stand of turfgrass within a 24 to 48 hour period. The fungus invades young leaf tissue and grows rapidly under warm temperatures (75 to 85°F) and the high humidities that can exist with excessive watering and high mowing of the turf. With cuttings of carnation, a soft, wet rot occurs at the point of callus formation. Infected plants wilt rapidly and die.

Hosts—*Rhizoctonia solani* has one of the largest host ranges of any fungal plant pathogen. The fungus causes disease in species in 530 genera of higher plants, including both dicots and monocots, from *Abelia* to *Zoysia* grass. The fungus causes seedling diseases and lower stem and root diseases of a large number of plants used in urban plantings in Arizona including aloe (*Aloe* spp.), ageratum (*Ageratum* spp.), aster (*Aster* spp.), coleus (*Coleus* spp.), chrysanthemum (*Chrysanthemum* spp.), carnation (*Dianthus* spp.), dichondra (*Dichondra* spp.), geranium (*Geranium* and *Pelargonium* spp.), iris (*Iris* spp.), lantana (*Lantana* spp.), lilies (*Lilium* spp.), marigold (*Tagetes* spp.), narcissus (*Narcissus* spp.), opuntia (*Opuntia* spp.), periwinkle (*Vinca* spp.), rose (*Rosa* spp.), snapdragon (*Antirrhinum* spp.), sweet alyssum (*Lobularia maritima*), sweet peas (*Lathyrus odoratus*), tulips (*Tulipa* spp.), violets (*Viola* spp.), and zinnia (*Zinnia* spp.). Many house plants such as African violets (*Saintpaulia* spp.), *Dieffenbachia*, *Syngonium*, *Peperomia*, and others are affected with basal stem rots caused by *R. solani*. Several lawn grasses are susceptible to damage caused by *R. solani*. They include bent grass (*Agrostis* spp.), bermuda grass (*Cynodon dactylon*), fescue (*Festuca* spp.), ryegrass (*Lolium* spp.), bluegrass (*Poa* spp.), zoysia (*Zoysia* spp.), and St. Augustine (*Stenotaphrum secundatum*).

Biology—*R. solani* commonly lives in the soil (soil borne) as a saprophyte. Quantitative estimations of soil populations of *R. solani* are based on sieving organic debris from the soil and determining the percent of debris that has been colonized by *R. solani*. This technique is based on the biological fact that *R. solani* aggressively grows as mycelium in soil and colonizes organic debris. The fungus survives in the debris by the production of thick walled mycelium (resting mycelium) or by the production of hard resting structures called sclerotia. Plant exudates stimulate mycelial growth from the resting mycelium or from the sclerotia. The mycelium then invades host tissue and causes lesions and girdling typical of the disease. This simple life cycle is complicated by the production, under certain conditions, of the perfect stage of the fungus which has been named *Thanatephorus cucumeris*. Basidia, specialized structures produced on host tissue under humid conditions, produce airborne spores called basidiospores. The basidia and basidiospores are minute and are only observable under a microscope. In our desert conditions, this

aerial, infective stage is rarely seen and is not important in the epidemiology of the disease. In humid areas of the world the basidiospores may initiate infection of leaves, flowers and fruit. All isolates of *R. solani* are identified by their typical mycelial growth characteristics. Also, all isolates have many nuclei in each cell of the mycelium and are considered to be the imperfect state of *Thanatephorus cucumeris*. The species exists in several non-interbreeding populations that vary in their host range. No studies have been made in Arizona on the host ranges of isolates recovered from urban landscape plants.

Rhizoctonia solani is a rapidly growing fungus that is easily isolated from infected tissue on simple media such as water agar.

Control—Urban plants are bought primarily from nurseries and other commercial suppliers. Pathogens may be introduced on planting material purchased from these facilities. The first step for control is the selection of vigorous, healthy plants at the time of purchase. Nurseries have a strict management program to produce healthy plants. The programs are based on fungicide treatment of seed (*Rhizoctonia* can be seed-borne), heat treatment of soil (30 minutes at a minimum of 140°F), fumigation of soil and sanitation of containers, benches, and tools.

VERTICILLIUM AND FUSARIUM WILTS

There are two unrelated soilborne pathogenic fungi that infect host plants through root tissue and become systemic in vascular (xylem) tissue. The plugging, enzyme and toxin production by growth of these fungi in water conducting tissue causes typical symptoms and often death of infected plants. These two fungi, both worldwide pathogens of hundreds of unrelated plants, are *Verticillium dahliae* and *Fusarium oxysporum*.

Both fungi are persistent in the soil for many years in the absence of any host. *Fusarium oxysporum* consists of many specialized forms which are specific to one host. *Verticillium dahliae* consists of several groups, some of which parasitize many hosts, and others which seem to be very host selective.

Both fungi invade and infect only the vascular tissue of host plants. Overlapping non-specific symptoms occur in plants infected by both pathogens. In general there is yellowing and drying of leaves, overall plant stress, wilting and death of branches, and varying degrees of vascular

discoloration. The only method to prove the cause of the disease is to isolate and identify the pathogen from infected vascular tissue.

Hosts of *Verticillium dahliae* include over 120 species in unrelated plant families including many woody and herbaceous ornamentals. Forms of *Fusarium oxysporum* cause disease in many food, fiber and ornamental plants. The species is one of the most important worldwide plant pathogens. Isolates are host specific. For example, an isolate from carnations is only pathogenic to certain cultivars in that species.

Interestingly, although both fungi occur naturally in Arizona soils only *V. dahliae* is an important plant pathogen. The lack of importance of *Fusarium* wilts (caused by biotypes of *F. oxysporum*) in Arizona is thought to be due to our alkaline soils which are not favorable for activity of the fungus. *Verticillium dahliae*, however, is an important plant pathogen of several of our important agricultural crops, including upland cotton (*Gossypium hirsutum*), peppers (*Capsicum* spp.), tomato (*Lycopersicon esculentum*), eggplant (*Solanum melongena*), okra (*Hibiscus esculentus*), and safflower (*Carthamus tinctorius*). Susceptible woody-landscape plants include olive (*Olea europaea*), pistachio (*Pistacia chinensis*, *P. vera*), ash (*Fraxinus* spp.), maple (*Acer* spp.), pecan (*Carya illinoensis*), carob (*Ceratonia siliqua*), almond, apricot, cherry, peach (*Prunus* spp.), California pepper tree (*Schinus molle*), elm (*Ulmus* spp.), rose (*Rosa* spp.), and privet (*Ligustrum* spp.). Ornamental plants susceptible to *Verticillium* wilt among others include; asters (*Aster* spp.), chrysanthemums (*Chrysanthemum* spp.), dahlia (*Dahlia* spp.), geranium and pelargonium (*Pelargonium* spp.), petunia (*Petunia* spp.), phlox (*Phlox* spp.), stock (*Matthiola* spp.), snaps (*Antirrhinum majus*), and sweet peas (*Lathyrus odoratus*). The list of resistant or immune plants is very large and includes all cacti; all monocots such as grasses, palms, iris and lilies; and all gymnosperms such as junipers, pines, and cypress.

Some other commonly planted shrubs and trees in Arizona that are resistant or immune to *Verticillium* wilt include: apples, citrus, eucalyptus, Pyracantha, mulberry, oak, oleander, sycamore, poplar, walnuts, and willows.

Although *Verticillium* wilt is common in several agricultural crops, the disease is less important in landscape plants. *Verticillium* wilt diseases of urban plants in Arizona seem to most commonly occur in plantings made in old agricultural land with a history of *Verticillium* wilt. This is because the fungus combines a wide host range with long term survival in the soil.

Biology of *V. dahliae*— One has to have great respect for the biological characteristics that make *V. dahliae* one of the most widespread and destructive soilborne fungal plant pathogens. These characteristics are: rapid host colonization via xylem (water conducting elements), production of large numbers of reproductive spores (conidia and microsclerotia), effective asexual mechanisms of variation, long term survival of microsclerotia in soil (up to 14 years in non-cropped field soils), wide host range, and effective dissemination mechanisms (microsclerotia are carried in air, dust, water, soil, plant residues, and in leaves, stems, and seed).

Another factor contributing to the success of *V. dahliae* as a plant pathogen in arid desert areas is the lack of dependence of the fungus on rain and high humidity for infection and host colonization (the fungus is internal in the host). Also, there are many plants (especially weeds) that, although susceptible to Verticillium wilt, show no symptoms when they are infected (symptomless carriers).

The fungus has a simple life cycle and produces only two types of reproductive structures: conidia and microsclerotia. The microscopic conidia are short lived but are factors in rapid internal host colonization. The microsclerotia are black, heavily walled, microscopic aggregates of fungal hyphae. The fungus can be identified under the microscope by noting the whorled arrangement of conidiophore branches and the typical clumped masses of the black microsclerotia.

Microsclerotia are produced in large numbers in infected host tissue during cool weather. They are returned to the soil on death of the host plant. They germinate in the soil to initiate root infection.

Symptoms and Biology of Verticillium Wilt of Olive—

Because of the importance of this disease in Arizona, it will be used as an example to discuss symptoms and biology of a typical *Verticillium* disease.

Verticillium initially invades the root system of olives when soil temperatures are cool. The fungus is relatively inactive at temperatures above 85 °F. After penetrating the roots, the fungus grows and moves through the plant in the water-conducting (vascular) tissues and eventually invades branches and twigs. This systemic invasion usually occurs from February to June. With the onset of high summer temperatures the fungus is inactivated. By then, unfortunately, the damage has been done and the trees begin to exhibit

symptoms. The presence of the fungus in the vascular system interrupts and reduces the water movement from the roots to the leaves. Wilt symptoms are attributable to impeded internal water flow.

Symptoms usually first appear in the spring near flowering time. Newer leaves roll inward and lose their deep-green, waxy luster and become dull gray and brown. Leaf-drop and twig die-back may follow, depending upon the severity of the infection and the effect of the environment on the water demand of leaves and fruit. Flower clusters on affected branches may die and remain attached. Individual branches, portions of trees or the entire crown may die in one season. Tree death, however, rarely occurs. New growth may develop from unaffected portions of the trees. Suckering from the crown may be prolific.

In Arizona, a slight vascular discoloration of affected twigs and branches may develop. This discoloration can be observed by removing the outside layer of bark from affected branches and exposing the vascular tissue.

When cool weather returns, the fungus again becomes active. In this way branches can be re-invaded each year during the spring season.

Control— Control of *Verticillium* wilt diseases is based primarily on the use of resistant cultivars or immune species. Many resistant cultivars of ornamental plants are available from nurseries and seed companies.

POWDERY MILDEW

Powdery mildew diseases occur on hundreds of plants grown in urban landscapes. The diseases primarily affect leaves, green stems, flower buds, and immature fruit of a wide range of plants including ornamental flowers, broad leaved shade trees, cereals, weeds, vegetables, fruit trees, and native plants. All of the powdery mildew fungi are obligate parasites and reproduce on living host tissue. They do not grow saprophytically. This is in contrast to the previously described fungi which combine saprophytic and parasitic stage in their life cycles. The powdery mildew fungi grow primarily on leaf surfaces and aerial plant parts. They are not systemic in plants, and they do not infect roots. The mycelium is superficial on host tissue in most genera, but in some such as *Oidiopsis*, the mycelium is internal. Chains of asexual colorless conidia are produced from conidiophores that grow from the mycelium. The name *powdery mildew* accurately describes the appearance of the fungus on host tissue. Nutrients are

obtained from host tissue by means of microscopic, rootlike organs called haustoria. These specialized fungal structures are produced only in epidermal cells.

Symptoms – Plants infected with powdery mildew fungi typically have a whitish, powdery covering over infected leaves, stems, and other aerial plant parts. Infected leaves are often curled or twisted. Severe leaf infection may cause leaf yellowing, reduced leaf size



Figure 11. Typical symptoms of powdery mildew on *Euonymus*. Note the superficial whitish blotches of mycelium on the upper leaf surface.

and defoliation. These symptoms are general. They are influenced by climate, host location (shade effects), host and the causal species of mildew.

The only real method of identification of a powdery mildew disease is to identify the host and the fungus. The fungus is easily identified under the microscope by the characteristic growth habit of the conidial (asexual stage) and by the architecture of the sexual fruiting body (cleistothecium). The conidial stage is always present. The sexual stage of the fungus may or may not be present.

Biology – Under mild winter conditions in the desert areas of Arizona, the powdery mildew fungi occur primarily in their asexual, conidial stage. The sexual stage is not important for survival. Thus, the life cycle is very simple. Conidia are wind carried to host tissue where they germinate and infect host tissue. The conidia germinate on dry leaf surfaces even when atmospheric

humidity is low. Spore germination and penetration of tissue usually occurs in 6 hours or less. Many species can produce a new generation of spores in 4 to 6 days under favorable conditions.

Some species of the powdery mildew fungi have very large host ranges. One of the most common species in Arizona is *Erysiphe cichoracearum*. This fungus causes powdery mildew diseases in species in over 160 genera of unrelated plants from *Ageratum* and *Antirrhinum* (snapdragons) to *Verbena* and *Zinnia*. Another species, *E. polygoni* attacks species in many genera of plants from *Acacia* to *Vicia* and *Vigna*. *Erysiphe graminis* causes powdery mildew of grasses.

Some powdery mildews of deciduous plants overwinter as dormant mycelium in leaf buds and in bark. In the spring the fungus becomes active and the conidial stage is produced. Powdery mildews that produce a sexual stage survive as cleistothecia. Sexual spores called ascospores are produced in the cleistothecia and are the primary source of infection during plant growth in the spring.

Control – Powdery mildews are controlled by the use of resistant varieties and also by a number of fungicides, including different formulations of sulfur. These chemicals are used as protective sprays, and it is very important to apply them at the first sign of disease since powdery mildew is extremely difficult to control once established.

RUST DISEASES

Rusts are an amazing group of fungi belonging to a single order of basidiomycetes, the Uredinales. Throughout history these fungi have been responsible for catastrophic diseases of many of the world's most important plants including grain crops such as barley, corn, oats, rye, sorghum, and wheat; vegetables such as asparagus and beans; field crops such as cotton, safflower, soybeans, and sunflower; trees such as apple, peaches, pines, firs, junipers, and oaks; and many ornamentals. Many plants found in urban environments in Arizona including asters, carnations, chrysanthemums, dichondra, geraniums, hollyhock, iris, lily, rose, and snapdragon are affected with rust diseases. Some common woody plants affected with rust diseases in Arizona include firs (*Abies* spp.), *Acacia* spp., cypress (*Cupressus* spp.), ocotillo (*Fouquieria splendens*), fairy duster (*Calliandra* spp.), junipers (*Juniperus* spp.), pines (*Pinus* spp.), aspen (*Populus* spp.), pear (*Pyrus communis*), and oaks (*Quercus* spp.).

Symptoms— Symptoms of rust diseases are almost as diverse as the fungi that cause the diseases. Some rust fungi have unbelievable, complex life cycles.

These life cycles may involve totally unrelated host plants and may include up to four different spore producing stages and five functionally different kinds of spores. Some species complete their entire life cycle on one host (autoecious) whereas other species require two hosts (heteroecious).

In order to understand symptoms caused by infections by the rust fungi, it is necessary to understand the various spore stages of the fungi. Infection by each spore stage causes somewhat different symptoms. Spore stages useful in identification of the disease include aecia, uredia, and telia. The aecia are cup and blister like in appearance. Light yellow to orange wind dispersed aeciospores are produced in the aecia. Uredia are also blisterlike pustules that produce masses of orange to rust-colored urediospores. Telia are structures that produce masses of teliospores. The telia follow uredia on the same host. The teliospores are usually black in color. Aecia, uredia, and telia can be easily observed on infected host tissue with the use of a hand lens. The spores, produced on each of these structures, however, are microscopic.

Identification of rusts may be complicated because many rusts omit one or more of the above stages. Also, aecia and uredia are somewhat similar in appearance. Symptoms of many rust diseases consist primarily of these small pustules on the underside of leaves.

Although the rust fungi most frequently attack leaves they also infect flowers, fruit, and stems and branches and trunks of woody flowering plants and conifers. Most rust infections are localized but in some diseases the fungi become locally systemic in host tissue and cause galls, blisters, and cankers in woody tissue.

Biology— The rust fungi, like the powdery mildew fungi, are all obligate parasites. Thus, it is impossible to isolate and grow these fungi in the laboratory. They complete their life cycles only on living host plants.

Variation in the life cycles of rust fungi can be dramatically illustrated by comparing three common rust diseases in Arizona: snapdragon rust (*Puccinia antirrhini*), hollyhock rust (*P. malvacearum*), and limb rust of Ponderosa pine (*Cronartium arizonicum*). The uredial and the telial stage occur on snapdragons and only the telial stage on hollyhock, respectively. In contrast to these two simple cycles is the complex

cycle of the limb rust pathogen. Aeciospores, produced from aecia on twigs of pine trees infect a totally unrelated host, paintbrush (*Castilleja integra*). Uredia and telia are produced on paintbrush. The urediospores infect only paintbrush. Teliospores, produced from telia on paintbrush, germinate and produce basidiospores that infect twigs of pine in the fall.

Snapdragon rust and hollyhock rust are examples of types of short cycle rusts and limb rust is an example of a long cycle rust. Almost any combination of spore stages is found in nature. The extraordinary biology of these fungi has fascinated plant pathologists throughout history. From an epidemiological consideration it should be noted that aeciospores in heteroecious rusts always infect the alternate host. Aeciospores may be aerially disseminated for hundreds of miles and remain viable. Urediospores normally infect the same host on which they develop. They may or may not be aerially disseminated for long distances. Basidiospores, produced from overwintering teliospores, are thin walled and delicate and are not adapted for long range spread. In heteroecious rusts (alternate hosts necessary for completion of life cycle) the basidiospores always infect the alternate host.

Control— The first step in controlling a rust disease, as with all plant diseases, is the identification of the causal fungus. The rust fungi are identified primarily by the anatomy of the aeciospores, urediospores and the teliospores. These spores are microscopic and must be examined with a compound microscope. Also, it is necessary to know the host species. Some hosts are infected by more than one species of rust fungi. Other hosts have only a single rust pathogen. Symptoms of each disease are different and very important in disease identification.

Control of rust disease is as complicated as the biology of the rust fungi. Each disease (there are thousands) may have a different method for control. Leaf diseases, in general, are controlled by the use of preventive foliar fungicides. The use of resistant cultivars, and seed treatments (some rust fungi are seed-borne) for control of certain rust diseases is beneficial. Most rust fungi are host specific. In the three diseases described, for example, snapdragon rust only attacks certain genetic lines of snapdragons. Hollyhock rust is similar. Limb rust of pine is also host specific. Within each species of rust fungi there are pathogenic races that cause disease in only certain cultivars within the host species.

These pathogenic races may vary from year to year and also be different in other geographical areas. Snapdragons, for example, bred for resistance to rust in one geographical area may be susceptible in other areas.

CYTOSPORA CANKER

Cytospora canker is commonly found on a number of fruit and shade trees in Arizona. This disease occurs worldwide on fruit trees, hardwood, forest and shade trees, shrubs and conifers. In Arizona the disease is most common on cottonwood (*Populus fremontii*), lombardy poplar (*P. nigra*), pecan (*Carya illinoensis*), and willows (*Salix* spp.). A number of *Prunus* spp. including apricot (*P. armeniaca*), peach (*P. persica*), plums (*P. salicina*), prunes (*P. domestica*) and cherry (*P. avium*) are susceptible. Occasionally the disease has been seen on apples (*Malus communis*). Over 40 pathogenic species of *Cytospora* have been described worldwide. The ascomycetous sexual stage has been named *Valsa* or *Leucostoma*. There is some confusion among authorities on the nomenclature of the causal fungus. The asexual, pycnidial stage, *Cytospora*, is the most common stage seen in Arizona.

Symptoms and Biology— Infections take place in above ground woody tissue that has been damaged by frost, fire or sunburn, or through wounds caused by pruning injuries and broken twigs and branches.

Typical symptoms of *Cytospora* canker are sunken lesions on infected tissue. The cankers are perennial and continue to enlarge each year. The fungus slowly invades and girdles limbs or trunks. The result is a dead limb above the infection site. Black pycnidia of *Cytospora* can easily be seen emerging from infected bark with use of a hand lens. The pycnidia are roundish and pinhead in size. They are scattered in the cankered area. During wet weather, sticky masses of orange-yellow conidia are extended in long tendrils. These conidia are wind disseminated to injured tissue where they germinate and infect host tissue. *Cytospora* is active during spring and summer. The extruded conidial stage is most commonly seen during our summer monsoon season. Inoculum can be found on cankered trunks and branches throughout the year.

Control— Sun damage may be reduced by shading or application of a white interior latex paint to woody tissue. Trees that are properly fertilized and watered are not normally susceptible to infection. Avoid severe pruning. Disinfect pruning cuts with a 1/10 dilution of a household bleach. Cut out infected branches as they are a continual source of infection. Remove and burn where feasible. There are no chemicals recommended for control. Removal of heavily infected cottonwoods near commercial pecan groves has reduced disease incidence in some situations.

SOOTY CANKER

Sooty canker, also known as branch or limb wilt, is caused by the fungus, *Hendersonula toruloidea*. This wound pathogen invades only sunburned bark or areas that have been mechanically injured, such as pruning wounds on smooth or thin barked deciduous trees. The fungus does not infect uninjured host tissue. In Arizona, disease is found primarily at low elevations where sunburn damage commonly occurs on trunks and branches of unprotected or stressed shrubs and trees.

The fungus has a wide host range and causes diseases in many unrelated plants.

Symptoms— The most common symptom of sooty canker is the sooty, black canker that develops beneath bark tissue. This black canker is due to the presence of masses of black, fungal spores that appear under the bark and on the surface of the canker. Symptoms on leaves of cankered branches appear during summer.

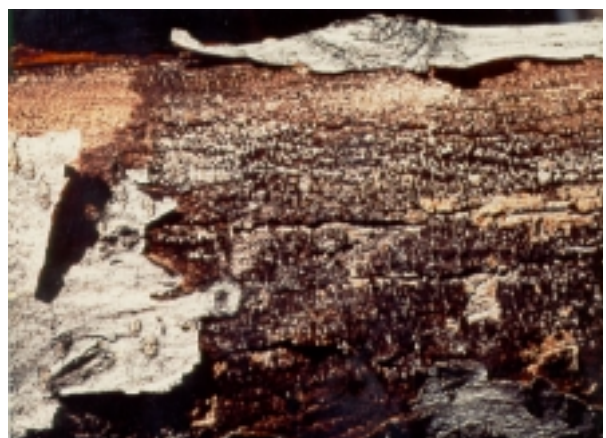


Figure 12. A close-up of a limb canker on cottonwood caused by the sooty canker fungus, *Hendersonula toruloidea*. Note the black masses of fungal spores that occur under the bark and on the surface of the canker.

Because the fungus grows into and kills sapwood, the leaves on branches with cankers, wilt, turn brown and die. Branches die back to the cankered area. Scattered branches are usually affected. Most cankers develop on unshaded trunks or limbs that face toward the sun. Sunburned trunks and limbs are highly susceptible to infection.

Biology of the Pathogen— The fungus, under our conditions, produces only conidia and thus has a very simple life cycle. The small conidia, produced in black, powdery masses under bark, are easily wind disseminated. These spores, which arise from segmented hyphae, are carried to damaged bark tissue where they germinate and initiate infection. Most active fungal growth occurs during the summer. The mycelium grows into living tissue. Infected sapwood becomes stained gray to black in color. Early research in California simulated sunburn damage on bark of walnut trees with use of a “blow-torch.” This fact says something about our summer conditions.

Common susceptible hosts in Arizona include: almond (*Prunus amygdalus*), apple (*Malus sylbestris*), apricot (*Prunus armeniaca*), ash (*Fraxinus spp.*), carob (*Ceratonia siliqua*), *Citrus spp.* (oranges, grapefruit, lemon, lime), cottonwood (*Populus spp.*), fig (*Ficus cariaca*), mimosa (*Albizia julibrissin*), mulberry (*Morus spp.*), peaches (*Prunus persica*), pecan (*Carya pecan*), plum (*Prunus domestica*), sycamore (*Platanus occidentalis*), walnut (*Juglans spp.*), and wisteria (*Wisteria spp.*)

Control— Sooty casnker can be controlled when infections are confined to limbs and upper branches. Smaller infected branches should be removed when symptoms appear. Since sunburned bark is the primary infection site, large limbs should be pruned only when trees are dormant.

When removing infected limbs, cut back to at least 1 foot below the canker. The cut area and pruning tools should be treated with a solution of 1 part household bleach and 9 parts water. Pruning wounds should be painted with a copper fungicide to prevent infection. Reapply the copper compound to the wound each spring to insure adequate protection against infection. Control becomes increasingly difficult as the disease progresses into the scaffold branches and is virtually impossible once the main trunk is infected.

Tree vigor should be maintained through proper fertilization and deep watering on a regular schedule. Severe pruning of larger branches and limbs of trees susceptible to sooty canker should be avoided. Whitewash, applied to exposed lower trunk areas, will reduce the possibilities of infection. This material reflects radiation and reduces bark temperature.

WOOD ROTS AND DECAYS

Wood-rotting basidiomycete fungi are occasional problems in desert plants including cliff rose (*Cowania spp.*), canotia (*Canotia holacantha*), palo verde (*Cercidium spp.*), creosote bush (*Larrea tridentata*) and junipers. Also, some cacti such as saguaro and cholla which have a large amount of solid, woody tissue may be invaded and decayed by wood-rotting Basidiomycetes as well as a number of landscape trees, including mulberry (*Morus spp.*), cottonwood and poplars (*Populus spp.*), and chinaberry (*Melia spp.*). Wood-rotting Basidiomycetes are common disease fungi in a large number of conifers, deciduous trees, shrubs, and hardwoods throughout the forest areas of Arizona. Large losses of timber on living and harvested trees are caused annually by these fungi. Weakening of limbs and the subsequent hazard from breakage of large limbs and trunks, especially on windy days or during wind storms, is a serious consequence of these infections.



Figure 13. A shelf-shaped mushroom of a wood decay fungus (*Ganoderma* sp.). A cross-section of this area would reveal the dark, rotted heartwood where the fungus is active.

Symptoms— In living trees and shrubs most rotting is confined to the older, central wood of stems and branches. The conks of these fungi appear near the infection site. These shelf-shaped fungal structures are most commonly seen along the main trunk and on infected branches. Cross sections of infected wood reveals the dark, discolored heartwood where the rot fungus is active. The fungus may be isolated from these tissues.

The fungi enter through wounds. Shelf-shaped or bracket-like structures usually occur after decay has been active for long periods of time. The disease progresses slowly and generally is not noticed until the fungus has destroyed heartwood.

Control— Control consists of removal of infected tissue and prevention of wounds to woody tissue. A specialist is necessary to identify these diseases and to give advice on specific control measures. In any case, affected limbs should be pruned away to avoid damage or injury if they fall.

GANODERMA ROOT ROT

Another basidiomycete, *Ganoderma lucidum*, causes root rot in native and landscape trees such as olive, African sumac, mulberry, hackberry, and oak. Another *Ganoderma* species causes root rot in mesquite and Acacia.

Biology and Symptoms—Spores of these *Ganoderma* species infect the roots of susceptible hosts, and as the fungus grows in host tissue, it causes root rot. Infected trees decline rapidly and die. The entire crown is affected as leaves fail to emerge. These fungi seem to be limited to the roots and lower crown. They are soil borne, and spread from plant to plant by root contact. The creamy colored mycelium of the fungus can be seen if the bark is pulled away from the root. During summer rains, the reproductive structures of these fungi may form on the base of the tree. These are white to reddish-orange fleshy growths on the bark that become hardened when they mature. Brownish-red spore deposits may be visible around the structures. These reproductive spores are easily carried in the wind.

Control— There is no control for *Ganoderma* root rot once the plant is infected. The best way to prevent infection is to prevent wounding. Cutting roots during construction or landscape maintenance should be avoided wherever possible.

BACTERIA

The desert environment of Arizona is not conducive to bacterial plant diseases. Foliar and above ground diseases that are of great importance in the wet, humid areas of the world, are rare and insignificant. There are some exceptions, however. Two gall diseases, crown gall and oleander gall are common. Also, fire blight, bacterial necrosis of saguaro, and bacterial wetwood or slime flux are significant enough for discussion in this publication.

CROWN GALL

Crown gall is caused by the soil-borne bacterium, *Agrobacterium tumefaciens*. This disease is one of the most widely studied of all plant diseases. This gall inducing bacterium enters plants through wounds primarily on lower stems and trunks and roots. Cellular growth is stimulated and galls of varying sizes and shapes are produced in infected plant tissue. *Agrobacterium tumefaciens* has the largest host range of any bacterial plant pathogen. More than 600 plant species in over 90 plant families are susceptible.

Symptoms— Galls form on stems and roots, especially at the root crown, the area where roots and stem come together. Galls enlarge with host plant growth. Gall formation does not occur in dormant plants. The galls range in size from less than 1/2 inch in diameter to over 8 inches in susceptible, older plants. The size of the galls is influenced by plant species and size and growth rate of the infected plant part. Galls on woody plants are spongy and light colored when young but with age become rough, hard and fissured. Old galls are often sloughed off.

Plants affected most commonly in Arizona include almonds, apples, apricots, cherry, cottonwood, figs, grapes, nectarine, peaches, pears, pecans, plums, privet, pyracantha, roses, and willows.

Biology— Strains of *Agrobacterium* can be isolated from soil, galls, and root surfaces. Crown gall bacteria are disseminated in soil, water and on or in plants. In grapes, for example, the bacterium becomes systemic in xylem tissue. In Arizona the most serious cases of crown gall have occurred where early spring growth is followed by freezing temperatures. This is more common at elevations above 3000 feet. This occurs because the bacterium is a wound pathogen. *Agrobacterium tumefaciens* survives in the soil as a root colonizer of many plants without regard to their

susceptibility to infection and gall formation. When susceptible hosts are planted into infested areas the bacteria infect through wounds and galls are produced. The bacteria are returned to the soil when galls disintegrate, thus completing the simple life cycle.

Control— It is very difficult to purchase disease-free plants because early galls are often too small to see or have not formed. Once the bacterium is introduced into your landscaping area for all practical purposes it is there indefinitely. The greatest economic losses caused by crown gall occur in nurseries that produce stone and pome fruit trees such as almond, apple, cherry, peach, and plum because regulations prohibit their shipment and sale. The damage caused by crown gall may have been historically exaggerated. Recent studies in grapes, for example, suggest that only very extensive galling causes reduced growth and yield loss. There is no practical method, although several have been suggested, to eradicate the galls. If crown gall has been a problem in the past, replant with resistant species such as palms, grasses or conifers. No chemical methods are recommended. Avoid injuries during planting of bare rooted and other ornamental plants.

A biological control may be available to prevent entry of the pathogen. A strain of bacterium that attaches to a wound site but does not cause disease can be used as a root dip or wound paint for preplant prevention. Development of resistance of the pathogen to this strain has been a problem.

OLEANDER GALL

Oleander (*Nerium oleander*) is one of the most popular evergreen shrubs in Arizona. The gall disease is widespread.

Symptoms and Biology— Oleander gall is caused by the bacterium *Pseudomonas syringae* pv. *savastanoi*. Galls occur on twigs, branches, leaves, flowers, and seedpods. Initially galls appear as small protuberances that subsequently develop into wart-like growths with roughened, fissured surfaces. Galls vary in size but average about 1/2 to 1 inch in diameter. Large galls are usually made up of several small galls that have grown together. Galls are the result of the growth and multiplication of the bacterium. The bacteria enter and infect oleanders through leaf and blossom scars, wounds produced by pruning, frost injury, and natural openings. Rain, sprinkler water, and pruning tools can spread bacteria from diseased to healthy plants.

Control— When purchasing oleanders, examine them carefully to be sure they are free of galls. The vast majority of nursery stock is free from disease but prevention is always the most effective method of disease control. For diseased oleanders, prune out infected plant parts and apply disinfection solution (a 10 percent solution of household bleach [one part bleach to nine parts water]) to each cut surface. Always dip pruning tools in the disinfectant solution between cuts to reduce the possibility of spreading the bacteria. Pruning operations should be conducted during the dry seasons to avoid infection of wounds. Avoid sprinkler irrigation.

Severe infection of large shrubs is difficult to control by selective pruning. If the entire shrub is cut down, the new succulent growth is extremely susceptible to infection. In certain situations, removal of the diseased plant and replanting may be the best method of control.

FIRE BLIGHT

Fire blight, caused by the bacterium *Erwinia amylovora*, is one of the oldest known and most serious bacterial plant diseases. Interestingly all susceptible plants are in the rose family (*Rosaceae*). The most important groups include apples (*Malus* spp.), pear (*Pyrus* spp.), cotoneaster (*Cotoneaster* spp.), hawthorn (*Crataegus* spp.), quince (*Cydonia* spp.), loquat (*Eriobotrya japonica*), Prunus spp. (including apricot, cherry, plum, prunes), pyracantha (*Pyracantha* spp.), mountain ash (*Sorbus* spp.), and spirea (*Spiraea* spp.). In Arizona most reports of fire blight relate to apples, pears, and pyracantha. The causal bacterium, *E. amylovora*, is thought to be indigenous to



Figure 14. Symptoms of fire blight on loquat. Note the infected brownish shoot tissue.

North America. The disease was first reported on apples, pears, and quinces in the Hudson River Valley of New York in 1780. In 1878, an American plant pathologist, Thomas Burrill, working at the University of Illinois, concluded that the disease was caused by a bacterium. The disease was not described in Europe for another 100 years.

Symptoms – Extensive studies on symptom development, basic biology and control have been made on apples and pears. Fewer studies have been made on other hosts including ornamentals and native plants. In Arizona fire blight is a problem in Cochise and Graham counties on pears and apples. The disease is occasionally a problem on loquat, cotoneaster, and pyracantha in urban situations. Our desert environment does not favor this disease in normal rainfall seasons.

Disease symptoms first appear when trees or shrubs are blooming. Blossom blight, an early symptom, occurs because the bacteria first invade flowers. The pathogen enters hosts through blossoms, wounds, and natural openings such as stomata, hydathodes, lenticels and nectaries.

In Arizona, if high humidity, high rainfall and warm cloudy weather occurs during the flowering cycle the pathogen can cause extensive damage. Infected blossoms of pear, apple, loquat or pyracantha develop a water-soaked appearance, shrivel, and turn brown to black. Affected flowers may or may not drop. Affected apple blossoms tend to cling to the spurs. Young, rapidly growing apple shoots and twigs also are quite susceptible. In the early stages of disease, reddish-brown streaking can be seen in the tissues below visible infections. Affected apple shoots eventually turn light to dark brown, while pear shoots turn dark brown to black. Affected leaves appear light to dark brown.

Blackening of petioles and the central main vein of leaves is common. Margins of advancing infections of pear fruitlets often have a dark green (water-soaked) appearance, while those of apples are reddish.

The pathogen also can invade major branches and trunks of trees, causing visible cankers. Cankers initially may have no obvious margins,

or the margins may be raised or appear as blisters. If a canker girdles a trunk, branch, or twig, the portion above usually dies.

Under warm, humid conditions the bacteria can multiply so rapidly that they will ooze from infected peduncles, shoots, leaves, fruits, and even cankers. Sticky and light to amber colored, such ooze may appear as droplets, tendrils, or discolored streaks. This is not a common phenomenon under Arizona conditions.

Disease Cycle – *Erwinia amylovora* survives between season within and on host tissues. The bacteria do not survive in soil.

Temperatures between approximately 60° and 85°F, humidity above 60 percent, and the frequent occurrence of free moisture (dews, rain, fog, sprinkler irrigation) favor the multiplication and spread of the pathogen. Bacteria are transferred from cankers to flower buds, new leaves, succulent shoots, and fruits by splashing water and insects. The bacteria penetrate plant parts via natural openings, including nectaries in flowers and stomata in new leaves and shoots. Penetration also can occur through fresh injuries such as those caused by hail or chewing insects. Bacteria are secondarily distributed from newly infected flowers and from ooze associated with infections to non-infected flowers, and leaves by insects and splashing water. Pruning tools also can be important in transferring bacteria from infected to non-infected branches. Once infection of flowers or leaves occurs, bacteria can move into shoots, and then upward and downward in the shoots without causing any external evidence of disease. In fact, bacteria have been recovered approximately 35 inches beyond the margins of visible lesions.

Control – Resistant varieties: Of the apple varieties commonly grown in Arizona, Arkansas Black and Red Astrachan are currently considered resistant. Golden Delicious, Red Delicious, Granny Smith, Jonagold, and Gravenstein are moderately resistant to fire blight. Rome Beauty, Jonathon, and Lodi are susceptible to the disease, as are most flowering crab apples. The predominant apple rootstocks used are rated for fire blight susceptibility as follows: MM111, light; MM106, moderate; M9, severe; and M26, very severe.

Currently, Bartley and Bosc pear varieties are considered highly susceptible, Seckel moderately resistant, and Surcrop resistant to the disease.

Chemical control— Chemical control of fire blight is based on protective sprays. Initiate spraying during the bud/bloom period when the average of daily maximum and minimum temperatures reaches 60 °F. Follow label recommendations for mixing and applying sprays, including the timing for repeat sprays (usually at five day intervals) during the blooming period, particularly when rain or hail has occurred since the last application. Since any unprotected, open blossom is a potential infection site, sprays should be continued throughout the bloom period when environmental conditions exist which are favorable for blight.

Two groups of chemicals have traditionally been used for blight control. These are:

- Copper compounds. Copper compounds can be effective in reducing fire blight. They are easy to apply and relatively inexpensive. Although bordeaux (copper sulphate plus lime) probably has been the most frequently used formulation, fixed coppers such as kocide (copper hydroxide) and copper oxychloride sulphate (COCS) are much easier to prepare and use as dormant and blossom sprays. However, copper can cause russet-ting of fruit which can decrease their fresh market value.
- Antibiotics. Streptomycin has been the antibiotic of choice in protective sprays. Although more expensive than copper compounds, streptomycin normally does not cause russetting. However, resistant strains of *E. amylovora* have developed in areas where streptomycin has been exclusively and repeatedly used.

Pruning/Sanitation— In the spring, remove infected shoots and flowers. Prune them off at least 15 inches below any visible symptoms. Pruning equipment should be decontaminated after every cut by treating the blades with 10 percent household bleach. Because of their susceptibility to *E. amylovora*, promptly remove unwanted suckers from trunks, roots, and scaffold branches. During the dormant period, remove all remaining blighted plant parts. All infected prunings (summer and winter) should be burned.



Figure 15. Symptoms of bacterial necrosis of saguaro. Note the black coming from the infection site above the two arms.

BACTERIAL NECROSIS OF SAGUARO

This disease is caused by soft-rotting species of *Erwinia*. The pathogen has also been recovered from a number of indigenous cacti including cholla, prickly pear, barrel, and organ-pipe cacti.

Symptoms and Biology— Symptoms appear at one or more positions on the trunk or branches of saguaros. The first indicator of bacterial necrosis is a circular darkening and softening of the plant tissues. The infected area enlarges, becoming purplish-black, and splits open. A dark odorous material will frequently “leak” from the plant. At other times, the soft areas dry and crack, revealing the dark, dry remains of diseased tissues. If conditions are favorable, the plant can confine the disease to a “pocket” by forming a barrier of protective tissue (callus) around the infected area. If this tissue does not rapidly form, the bacteria will spread.

Bacteria occur in the diseased plant tissue of living cacti, and in the exudate associated with the infected areas. Infection begins when the pathogen is introduced into the cactus through wounds or natural openings. Presumably, insects and small animals which are associated with diseased or decaying saguaros serve as the principle carriers.

Control— Removal of diseased tissue is the most practical way to control the spread of the infection within the plant. If the affected area is small, remove all the rotting material and about one-half inch of the surrounding healthy tissues. Slope the bottom of the excavation so that water will drain out. The wall of the

cleaned rot pocket should be smooth. In removing the rotting material, be careful not to make “puncture-type” cuts into the remaining healthy tissue since the pathogen can survive in such sites. Thoroughly wash the cleansed pocket with a 10 percent household bleach solution (1 part household bleach and 9 parts of water; also include about one teaspoon of liquid detergent per gallon of solution) and then allow the pocket to stand open to hasten healing.

If the lesion is so large as to nearly girdle or weaken an arm or plant, serious consideration should be given to removal of the affected structure. Otherwise, damage might result should the branch or plant unexpectedly fall.

WETWOOD OR SLIME FLUX

These two diseases are described under bacterial diseases because a number of diverse bacteria, including *Erwinia* spp., are thought to be the cause of these poorly understood diseases. In the literature the disease is referred to as slime flux and/or wetwood.

Symptoms— Symptoms of Slime Flux consist of water-soaked, discolored areas at or below branch crotches and trunk wounds with chronic bleeding of sap. Wilting and die back of branches may occur. Water-soaked wood with large numbers of bacteria is discolored and dead. Liquid may seep out of cracks and wounds and run down the bark. The liquid, because of contamination with microorganisms, becomes dark in color, sticky and odiferous. Fermentation of tree tissues may cause increases of pressure and toxin production within the infected tree. Normally, the disease is not found in young trees. This is probably due to the fact that in the sapwood and heartwood of normal, young actively growing trees, bacteria and fungi are rare. Susceptible hosts in Arizona include: ash (*Fraxinus* spp.), elms (*Ulmus* spp.), cottonwood (*Populus fremontii*), mulberry (*Morus* spp.) and mesquite, common and chilean (*Prosopis juliflora* and *P. chilensis*).

Control— There are no preventative methods for Slime Flux except good tree health care practices, proper watering, feeding and pruning. There are no controls for the disease. The practice of installing tubes to drain liquid is no longer recommended since it does not alleviate the problem and the holes are a good infection site for many pathogenic organisms. Trees with Slime Flux will usually live for many years, but any weakened limb

should be removed if it is a safety risk. If the dripping causes stains on patios or walkways, a hard water spray, applied routinely, may prevent staining

Nematodes

It is beyond the scope of this publication to go into detail concerning diseases caused by nematodes. There are hundreds of species that parasitize plants. Most plant-parasitic nematodes attack only roots. Symptoms on roots cover the range from swelling, lesions, galls, and suppression of root elongation. Above ground symptoms are non-specific and consist of slow growth, chlorosis and all symptoms associated with root damage and nutrient deficiencies. Specific diagnosis requires the analysis of root and soil tissue to determine qualitative and quantitative populations of nematodes.

ROOT-KNOT NEMATODES

(*Meloidogyne* spp.) These nematodes are the most common and important group. They cause disease in hundreds of plants including ornamentals, vegetables and the following commonly planted landscape trees; Acacia (*Acacia* spp.), almonds (*Prunus* spp.), apricots (*Prunus* spp.), Arizona ash (*Fraxinus velutina*), Chinese elm (*Ulmus parvifolia*), fig (*Ficus carica*), peach (*Pyrus* spp.), pear (*Pyrus communis*), plum (*Prunus* spp.), pomegranate (*Punica granatum*), weeping willow (*Salix babylonica*), golden willow (*Salix alba* ‘Tristis’), bottle tree (*Brachychiton populneus*), olive (*Olea europaea*), palm (*Phoenix canariensis* and *P. dactylifera*, *Washingtonia filifera* and *W. robusta*, *Chamaerops humilis*, *Arecastrum romanzoffianum*, *Trachycarpus fortunei*), and Japanese privet (*Ligustrum japonicum*).



Figure 16. Root-knot nematode on roots of an annual, herbaceous plant. Note the galls of varying sizes on the roots.

Symptoms— Plants are stunted with small, pale green or chlorotic foliage that tends to wilt and partially defoliate in warm weather. Flower production and fruit set are reduced. Irregular, spherical swellings (knots) are found on the roots at the point of nematode feeding.

Control—Control is based on first identifying the nematode. Then it is possible to implement certain cultural techniques such as the use of resistant plants and varieties, rotation, and fallow. Purchase plants from reputable nurseries and producers.

Parasitic Higher Plants

Over 2500 species of higher plants live parasitically only on other living plants. The most important genera worldwide include dwarf mistletoes of conifers (*Arceuthobium* spp.), mistletoes on broadleaved trees (*Phoradendron* spp.), the European true mistletoes (*Viscum* spp.), broomrape (*Orobancha* spp.), witchweed (*Striga* spp.), and dodder (*Cuscuta* spp.). All of these parasitic plants produce leaves, stems, flowers, and seeds but no true roots. The mistletoes have chlorophyll but depend on their hosts for water and nutrients. Others, like dodder, have little or no chlorophyll and no true roots. The dodders are totally dependant on their hosts for completion of their life cycles.

MISTLETOES

In Arizona, although dodder and broomrape are occasionally seen on a number of broad-leaved plants, the most important and common parasitic plants in this group are the mistletoes. Two groups are important, the dwarf mistletoes of conifers and the true mistletoes of broadleaved trees and shrubs. Dwarf mistletoes are common problems in our conifer forests.

In urban plantings in the desert areas of Arizona the only significant mistletoes are the true mistletoes caused by *Phoradendron* spp. Several *Phoradendron* spp. have been described in Arizona including *P. californicum* (parasitic on leguminous shrubs and trees such as acacia (*Acacia* spp.), blue palo verde (*Cercidium floridum*), foothill palo verde (*Cercidium microphyllum*), Mexican palo verde (*Parkinsonia aculeata*), ironwood (*Olneya tesota*) and mesquite (*Prosopis* spp.). Other *Phoradendron* spp. occur on juniper (*Juniperus* spp.) and oak (*Quercus* spp.).

The most conspicuous and largest leaved mistletoe in Arizona is *P. tomentosum* which parasitizes cottonwood (*Populus fremontii*), sycamore (*Platanus wrightii*), ash

(*Fraxinus* spp.), hackberry (*Celtis* spp.), walnut (*Juglans* spp.), and willow (*Salix* spp.). It is often a serious problem along rivers and streams, washes and in parks and golf courses with large cottonwood trees.

Symptoms and Biology— One of the most common sights in areas where these hosts grow is the green, straggly, bushy growth of mistletoe hanging from infected branches. The true mistletoes are spread by birds that eat the berries and deposit the viable seeds with their feces. Seeds germinate on the host plant and cause new infections.

Often the mistletoe completely takes over the plant and death occurs. This is a long process. Heavily infected desert shrubs and trees have been infected for many years. Mistletoe plants are often so numerous as to obscure the host plant. *Phoradendron* spp. are perennial evergreens. Thus, deciduous trees, like cottonwoods, appear almost as evergreens during the winter if infection is heavy.

Infected branches and stems become swollen. The mistletoe itself grows into the plant well beyond the visible its growth on the plant. Slow, progressive decline and death of branches may occur. Infections on lower trunks, which are fairly common in desert legumes, are more damaging to the tree than infections that occur on upper branches. Dead or dying branches are weakened and become susceptible to breakage.

Control— Mistletoes are very difficult to control. The only practical method of control is to prune out infected branches approximately one foot below the infected sites. Also, the mistletoe plant should be physically removed at least annually in situations where pruning (lower trunk infection) may not be feasible.

Nonparasitic Diseases

Many plant diseases that occur in our diverse climate zones are not caused by parasitic micro-organisms but are nonparasitic in nature. Soil conditions where these nonparasitic diseases are common include high pH (alkaline soils), saline soils (salt contents with electrical conductivity measurements of 4 mmhos per cm or greater from a saturated soil extract, ECe), sodic soils (exchangeable sodium percentages, ESP of 15 or greater), low soil organic matter content, poor soil moisture holding characteristics, shallow soils, poor soil structure, and caliche deposits. Weather conditions contributing to these diseases include intense summer heat, low

humidities, drying winds, low rainfall and unpredictable freezes. Other factors include inappropriate plant selection, poor pre-plant soil preparation, inadequate or excessive fertilization, improper watering techniques (particularly in drip irrigation systems) and damage caused by herbicides.

Some of our most common nonparasitic diseases are:

ALEPPO PINE BLIGHT

Symptoms— This physiological disease only occurs on the commonly planted Aleppo pine (*Pinus halepensis*). Death of needles, twigs, and branches occurs usually in trees over 5 years of age. Most symptoms develop in the upper part of the tree. Blighted needles take on a gray-green color that later turns reddish-brown. These needles may persist on the tree until their seasonal summer defoliation. Some twig and small-branch death may follow needle blight.

Conditions Favoring Disease— Aleppo pines planted in shallow or poorly draining soils are particularly subject to drought stress. Poor soil drainage caused by underlying hard-pan contributes to blight by hampering root development. Drying winds and low relative humidity during fall and spring are commonly associated with the onset of symptoms.

Control— Maintain a uniform deep water supply to the tree throughout the year. Irrigate so that water is available to a depth of at least 5 feet for mature trees. Apply about 1/4 cup of nitrogen fertilizer per inch of the trunk in diameter. Apply one-half the fertilizer in March and the other half in July.

SCORCH

Symptoms— This disease occurs during hot, dry, windy weather. It is characterized by marginal browning and drying of foliage. The roots of the plant fail to take up sufficient moisture to make up for the heavy amounts of moisture lost during the dry, hot period. Deep, thorough irrigations at 2 to 3 week intervals may help prevent this problem. This symptom, caused by water stress during our hot, dry summer period is common to many trees, shrubs and ornamentals.

ARIZONA ASH DECLINE (*Fraxinus velutina*)

Symptoms— Branches may exhibit symptoms of leaf tip and edge burning. These symptoms are similar to those

associated with drought or excess salts. Leaves are usually small, and elongation of internodes is reduced, causing a tufted or rosette appearance. Dead leaves often remain attached to the affected limbs. Dieback becomes noticeable beginning about July. As the decline progresses entire branches and limbs die until the whole tree is killed.

Conditions Favoring the Disease— The disease has been observed throughout the state wherever ash trees are cultivated (at elevations ranging from 1,300 to 5,700 feet). As a native of southwestern Arizona, Arizona ash is relatively tolerant of drought and alkali. Well fertilized, deeply irrigated ash trees appear more able to compensate for the dieback and remain lush in spite of being affected.

Control— Maintaining trees in a vigorous condition will help reduce the rate and severity of decline. Frequent (weekly to biweekly for mature trees), deep irrigations during the hot summer months and at least monthly irrigations in the cool seasons are recommended.

MULBERRY TREE DECLINE (*Morus* spp.)

Symptoms— Symptoms consist primarily of small leaves and dieback of the upper twigs and branches. The disease usually appears in trees that are 15 to 20 years of age. The overall tree decline is slow, but death may occur 2 or 3 years after the initial symptoms.

Causes of Disease— There are many possible factors involved in any tree decline disease. One of the major factors, however, is insufficient watering, particularly in trees that are in lawn situations.

Control— The mulberry tree needs infrequent (once a month) deep (4 feet) irrigations particularly during the summer months. Tree wells should extend to the drip line of the tree.

OLEANDER DECLINE (*Nerium* spp.)

Symptoms— Because of the stiff, leathery leaves and woody stems and branches, wilting is not commonly observed in oleander. Instead, in response to water stress, foliage turns dull gray-green in appearance and becomes brittle. Lower leaves turn yellow, dry, and drop off.

Control— If a watering basin is used, it should be three to four inches deep and extend out from the base of the plant to the drip line. Basins should be filled at each irrigation in order to saturate soil to a depth of at least three feet.

These 5 diseases are examples of water stress conditions. The symptoms are similar in most of the non native, introduced shrubs and trees. This disease is often noticed in poorly designed drip irrigation systems. Superficial sprinkling, instead of deep basin waterings, are a major factor in these problems.

SALT PROBLEMS

The most common nonparasitic disease in our desert areas is damage caused by excessive soil salts. Factors that increase salt accumulation in our desert soils include: poor drainage caused by dense subsoil layers and caliche deposits, inadequate leaching which allows salt accumulation in the rooting area, excessive salt in irrigation water, low rainfall and high temperatures, and excessive applications of fertilizer and manure. Symptoms of salt damage include plant stunting, marginal burning of leaves, and premature defoliation. Salt tolerance of urban plants to salt damage varies greatly. Symptoms of salt damage are nonspecific.

There are many causes of the above described symptoms including root diseases, insects, mineral deficiencies and excesses, and herbicide damage. Diagnosis of salt problems requires the taking of a soil sample in the root area of the affected plant. Tissue analysis may also be necessary.

MISCELLANEOUS PROBLEMS

Other nonparasitic problems include a wide range of conditions from lightning damage, frost and freezing damage, sun scald, nutrient deficiencies, pesticide damage and air pollution. Professional help is necessary to

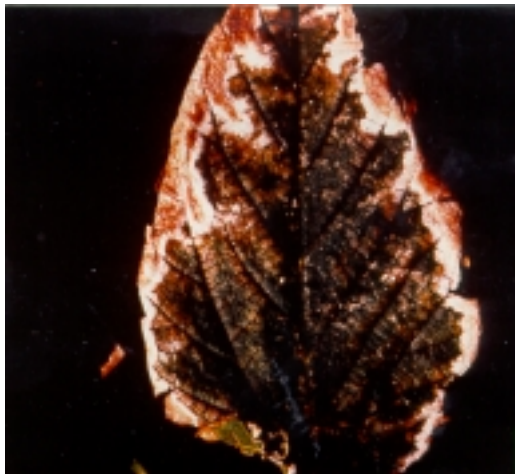


Figure 17. A symptom (marginal leaf burning) that is the result of high soil salts. This symptom is commonly seen in many ornamental plants.

determine the cause of many of these problems. Some, however, like lightning damage, frost damage, extreme water stress, and pesticide damage, can be diagnosed with only the use of a little common sense. Nutrient problems, salt damage, and air pollution require professional help for diagnosis and control.



Figure 18. Leaf symptoms caused by deficiencies of zinc and/or iron in citrus.



Figure 19. Leaf symptoms caused by deficiencies of zinc and/or iron in grapes.

Another common problem in Arizona is the planting of shrubs, trees, and ornamentals that are not adapted to our climates and soils. Local horticulturists and landscapers should be consulted before attempting to landscape a specific location.



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