SOIL-BORNE FUNGUS DISEASES OF ORNAMENTALS

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Soil-borne fungus pathogens exist in soil, water, or in or on infected roots. Fungi may also reside in crown and foliar tissue as both mycelium, spores or resting structures such as sclerotia or chlamydospores. Spores or resting structures may be transmitted by tools, equipment, pots, benches, flats, shoes or any other items that may harbor bits of infested soil.

Fungus propagules may be disseminated in water used for irrigation, in soil used in containers, and with soil particles splashed, blown, or otherwise moved to susceptible plants. Soil insects may also transmit pathogenic soil-borne fungi. Soil-borne fungi comonly invade plants at or below the soil line and disease development begins before top symptoms are detected. During prolonged periods of high humidity accompanied by splashing water, fungi such as *Phytopthora, Rhizoctonia, Cylindrocladium, Sclerotium* and *Pythium* infect and colonize stems, petioles and occasionally leaf tissue. The youngest tissues are the most susceptible with resistance increasing as the host tissue matures.

PATHOGENIC FUNGI THAT CAUSE ROOT ROT

Rhizoctonia. This fungus has been reported to cause more different types of diseases, to a wider variety of plants, over a larger part of the world, and under more diverse environmental conditions, than any other plant pathogen. Rhizoctonia survives as thick-walled mycelium and sclerotia in the soil and in plant debris. All plant parts are attacked with the greatest amount of damage to roots. Not only are most field soils infested, but we have observed that pine bark will support survival of the fungus and infection of cuttings. Rhizoctonia may cause a severe aerial (foliar) web or thread blight during propagation with colonization of leaves and stems of plants crowded in containers.

Growers identify *Rhizoctonia* infection by the reddish-brown mycelium resembling fine threads or webs that appear on diseased tissue. In addition the mycelium or threads can be noted on the soil surface growing among soil particles. Mycelial threads fasten infected leaves of cutting to the particles of the propagation medium, making it difficult to lift the infected leaves. Leaves in close proximity to one another on crowded plants will have mycelium evident as webs that tie the infected leaves together and prevent them from falling off the plant.

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Phytophthora. Several different species of *Phytophthora* infect ornamentals. They all belong to the group commonly referred to as water molds and attack roots, stems, foliage, fruits, tubers, rhizomes and seed. Survival in the soil in the absence of a suitable host occurs as oospores, chlamydosores and mycelium in the tissues of host plants. Symptoms of infection are apparent as water-soaked mushy roots which turn dark brown to black when they dry, leading to complete destruction of affected tissue. On stems sunken cankers cause girdling, leading to top wilt and eventual death. Some species are restricted to roots whereas others cause leaf spots, leaf blights, collar rot and stem rot.

Disease development is rapid if the growing medium is poorly drained or kept wet for extended periods. Frequent wetting of the leaves and stems provides favorable conditions for leaf and stem infection. Wide spacing of plants, culture on benches above ground, well-drained growing media, and proper management of water will prevent serious disease.

Pythium. Mature tissues of plants are not generally infected by *Pythium*. Seeds, seedlings, young roots and stems are susceptible. Warm-wet or cool-wet soils favor disease. Several species of this fungus are reported to cause root rot and the different species have different optimum conditions for growth. Resting structures like oospores allow these fungi to survive during adverse environmental conditions. Once established in a crop area *Pythium* is difficult to eliminate. Water stored in irrigation ponds, running water, soil and peat-moss are all sources of *Pythium*. Hot water dips have been used successfully to eliminate the fungus and may be used if infected plant parts must be used for propagation. There are several species of *Pythium* that have been recovered from the roots of diseased ornamentals, including *P. splendens*, *P. irregulare* and *P. aphanidermatum*.

Sclerotium rolfsii. Diseases caused by this fungus are commonly referred to as "Southern Blight" or "Southern Stem Rot." Usually the fungus invades the stem region near the soil line and is particularly severe in propagation. There are many hosts with at least 500 species susceptible.

The fungus survives between periods of pathogenicity as sclerotia in plant debris and soil and can remain viable up to 5 years. High soil moisture, acid pH (3.0-5.0), optimum temperature of 25°-35°C (77° to 95°F) and adequate aeration favor a high incidence of this fungus. Movement of the fungus occurs by wind, water, infected propagative stock, or by transplants and infested plant debris. The symptoms of disease are wilting of the plant, preceded by water-soaked, usually brown, stem lesions at or near the soil line. Coarse white mycelium appears on the lesions and radiate over the soil surface and is interspersed with small, round, light tan to dark brown sclerotia which resemble mustard seeds. Diseased plants become girdled, frequently collapse and die. Various kinds of propagative material are infected including cuttings, tubers, corms, rhizomes and bulbs. Plant material that becomes infected should be removed and destroyed so that the sclerotia are not spread. If the medium used for propagation has become infested with the fungus, it should be discarded. Soil from fields in which susceptible crops have been grown should be avoided. These include peanut, soybeans, tobacco and tomatoes.

Fusarium. There are many species and forms of *Fusarium*. They have been implicated in the decay of bulbs, corms, tubers and seed. Dry root rots and vascular wilts are symptoms of certain species. Others cause damping-off and stem cankers. Diseases caused by *Fusarium* are more prevalent during warm to hot periods and are not measurably affected by changes in soil moisture Spread of the fungus occurs on propagative material, seedling transplants, wind-borne soil, surface drainage water, and contaminated implements and equipment.

Sclerotinia. Cottony rot is a commonly used term for the disease caused by this fungus. A prominent mass of white, lace-like mycelium produced on the host plant is a characteristic feature of this fungus. Roots, stems, leaves, petioles, flowers, fruits and storage organs are susceptible. Large, black and easily seen sclerotia of this fungus persist in the soil, usually within the top four inches of soil. The sclerotia germinate to produce mycelium or fruiting structures (apothecia) which produces spores that are wind-borne or splashed onto new hosts.

Thielaviopsis basicola. This fungus is a soil-inhabiting fungus attacking the roots and hypocotyls of many ornamentals. The disease has been found to be affected by environmental factors such as pH, temperature, soil moisture levels, organic matter, and aeration. Survival of the fungus in soil appears to be influenced by aeration, organic residue, by pH, and by antagonistic organisms.

This fungus formerly was well known for its importance in poinsettia production. However, largely through sanitation, now the fungus is rarely found associated with poinsettia roots. Recently we have found Japanese holly (*Ilex crenata*) to be a host with severe damage occurring in some cultivars. Other species of *Ilex* like Chinese and English holly have a high degree of tolerance to this fungus found on Japanese holly.

Thielaviopsis has two main spore forms, hyaline thin-walled endoconidia and large, thick-walled chlamydospores. Both types are produced in abundance or in or on infected tissue. Chlamydospores appear to be the main propagule responsible for the long period of survival in the soil.

Cylindrocladium. Several species of this fungus have been reported causing leaf spot, wilt and root rot on azalea, vomitoria holly and magnolia. The principal species involved in woody ornamentals disease are *C scoparium* and *C. floridanum* Disease incidence and severity are closely related to high humidity.

When cuttings are infected, there is poor root development. Leaf spots on azaleas are circular to irregular in shape and reddish brown, occurring at the tip or margin of the leaf. The wilt phase is closely related to stem canker development. Brown to black cankers form near the soil line and soon the vascular tissue becomes infected This is followed by a rapid wilting of the leaves starting with the top branches of the plant. Brown mycelial growth may be seen on both leaves and stem cankers, particularly during high humidity.

Cuttings should only be collected from healthy stock plants. Fungicides may be applied to the stock and to the cuttings.

MANAGEMENT OF ROOT ROT DISEASES

Pathogens are introduced into the plant production system in a variety of ways. It has been stated frequently that soil is the most common vehicle but water and such components of soilless or artificial media as peat moss and pine bark are also possible sources of pathogens. Growers who use soil in containers should pasteurize it before using, preferably with aerated steam, or fumigate with a volatile chemical to eradicate the resistant structures such as sclerotia and chlamydospores. The implements used in the greenhouse or in the field should be frequently sterilized to eradicate fungi and bacteria. Propagation and growing benches should be raised above the ground and disinfested between crops. Growing media that is pasteurized with steam (180°F for 30 minutes) to eliminate pathogens also has its competitive microflora eliminated and is readily recolonized by fungi like *Pythium* through unsanitary practices. Pasteurization with aerated steam at 140° to 160°F does not eradicate competitive beneficial organisms and the medium is therefore not readily recolonized by pathogens.

It is common practice to fumigate fields with volatile chemicals like mixtures of methyl bromide and chloropicrin to eradicate all of the fungi, nematodes, and weed seeds, before planting high value crops. Because many of the beneficial competitive organisms are eliminated through fumigation, reintroduction and recolonization by pathogens can occur readily. Machinery from infested fields can carry pathogen-infested soil into a fumigated field and result in severe disease in the next crop.

Plant production in containers placed on plastic is a popular method of culture. One advantage is breaking the direct contact of the container with the soil. However, depressions in the plastic can become puddles causing containers to be temporarily water logged and they also provide for movement of water molds to adjacent containers. Crowned growing beds partially eliminate the problem. A better solution is the construction of raised gravel or stone beds three to four inches in thickness to prevent the accumulation of water around the container.

Artificial or soilless media in containers must be adequately aerated with sufficient non-capillary pore space to allow rapid drainage after irrigation or heavy rainfall. Water mold-incited diseases are less severe in well-aerated media. Media that contain high volumes of small particle materials have little non-capillary pore space and retain large quantities of water leading to root rot.

Water used for irrigation can carry pathogenic fungi like *Phytophthora, Pythium* and *Rhizoctonia*. Surface bodies of water and occasionally running water can serve as a reservoir for plant pathogens. If water is recycled for irrigation, pathogens can be introduced into a previously non-contaminated medium. Wherever possible, well water should be used. City water that has been chlorinated for human consumption is recommended for propagation. If surface water supplies are suspected of carrying pathogenic fungi they should be assayed and chlorinated if found to be infested.

One of the major problems in the ornamental industry is the unavailability of stock free of pathogens, whether it be cuttings, liners or container plants. Rooted cuttings or liners may appear healthy, but when grown under conditions of high temperature and wet soil the roots will rot and they will die. Under cool conditions Japanese holly infected with the fungus *Thielaviopsis* suffer severe root rot. The infected plants make partial recovery under warmer growing conditions. In different regions of the country growers have learned how to grow ornamentals visibly free of symptoms, although still infected with root-rotting pathogens. However, when these infected plants are shipped to other states with different cultural and environmental conditions, symptoms may appear. Different environmental stress factors are required for different host-pathogen relationships.

Chemicals play a role in the protection of plants from infection. They do not eradicate established infections. Poor or even total lack of control usually occurs when the plants treated with fungicides are already infected. Failure to accurately diagnose the disease or selection of an ineffective chemical is often a source of grower frustration and wasted money. Overprotection or excessive application of chemicals is inappropriate not only from the viewpoint of unnecessary cost, but also the unacceptable environmental pollution. Because the ornamental grower faces the prospect of controlling many different soil-borne pathogens, frequently on the same plant and often on a wide variety of plants, the choice of chemicals and the correct rate of application schedule require considerable experience and knowledge. For this reason consultants can play an important role in the development of the most efficaceous program. Soil fungicides are applied as drenches or granules. The volume of drench applied depends in part upon the size of container, depth of flats or ground beds and the constituents used in the soilless or artificial mix. Granules or wettable powders incorporated into the growing medium offer a method that may become more important in the future. The advantages of fungicide incorporation are both economical and time saving. Granules are potentially in contact with all the medium particles if they are uniformly mixed and avoid the necessity of a drench application to place the toxicant in contact with the particles. There is also the possibility that granules will have a longer period of activity. New, as yet unregistered fungicides, like Ridomil® and Aliette® offer considerable promise for the future. Fungicides recommended for protection of ornamentals against root rotting fungi are listed in Table 1.

Recent publications have identified root-rot tolerant or resistant cultivars of rhododendrons, azaleas, junipers, and hollies. In the future more emphasis should be placed on the breeding of disease-resistant cultivars instead of relying on chance for resistance.

Table 1. Fungicides for controlling soil-borne fungus root rots

Fungicide	Recommended rate	Fungi protected against
Banrot 40% W (thiophanate methyl plus ethazol)	6-12 oz/100	*Fusarium, Rhizoctonia, Phythium, Phytophthora, Thielaviopsis*
Benlate 50% W (benomyl)	8 oz/100	*Fusarium, Rhizoctonia, Sclerotinia, Cylindrocladium, Thielaviopsis*
Captan 50% W (captan)	32 oz/100	*Phythium, Phytophthora*
Truban 30% W or 5% G (ethazol)	8-12 oz/100 or 10 oz/cu yd	*Pythium, Phytophthora*
Terrazole 35% W (ethazol)	8-12 oz/100	*Phythium, Phytophthora*
Lesan 35% W (diazoben)	10 oz/100	*Pythium, Phytophthora*
Terraclor 75% W (PCNB)	12-24 oz/100	*Sclerotinia, Sclerotium, Rhizoctonia*

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