



## PHYTOPHTHORA ROOT ROT AND DIEBACK OF RHODODENDRONS AND AZALEAS IN THE MIDWEST

Species of *Rhododendron*, which include azaleas as well as rhododendrons, are colorful flowering shrubs that are beautiful additions to any landscape. Unfortunately, these plants are attacked by two very widespread and serious disease complexes: root rot and dieback.

Rhododendrons grow best in a location protected from excessive wind and sun, in a porous, well-drained soil with high-moisture-holding capacity (preferably with an abundance of organic matter) with an acid reaction (pH 4.5 to 5.5); and with an organic mulch of good insulating quality covering the soil surface.

Root rot or Rhododendron wilt (Figures 1, 2, and 3) in the Midwest is caused by the soilborne fungi *Phytophthora cinnamomi* and *P. cactorum*. *Phytophthora cactorum*, which is widespread in temperate regions is known to infect at least 154 genera of vascular plants in 54 families. In the Midwest it has been reported attacking Catawba rhododendron (*R. Catawbiense*), rosebay rhododendron (*R. Maximum*) and azaleas (*R. spp.*). *P. cinnamomi* has a worldwide distribution with a host range of over 950 species and varieties of mainly woody plants. In the Midwest it is known to infect California rosebay (*R. Macrophyllum*) and Hiryu azalea (*R. obtusum*). *Phytophthora parasitica* is a common root-rotting fungus of greenhouse azaleas. In addition, several species of *Pythium*, which are common soilborne fungi, may also be involved in the root-rot syndrome, but their relative importance is presently unknown. Phytophthora root rot is most widespread and severe in nurseries on 1- and 2-year old plants. It is most common on field-grown plants growing in heavy, poorly drained soils. Disease development is favored by high soil moisture and soil temperatures of 80°F (26.7°C) and above. The disease is most serious during June, July and August. Temperatures of field soils and container

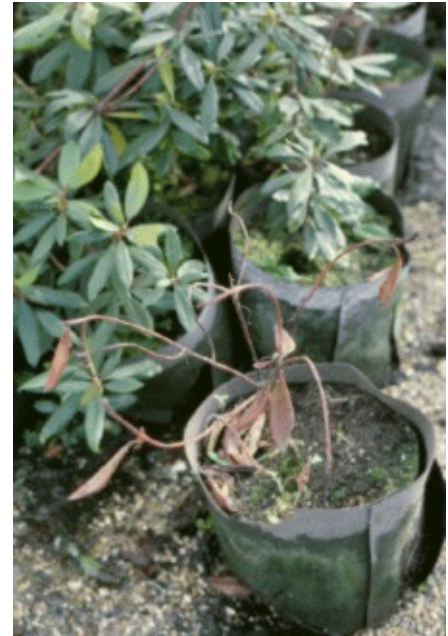


Figure 1. Rhododendron dieback caused by *Phytophthora cinnamomi*.



Figure 2. Rhododendron root rot caused by *Phytophthora cactorum* (courtesy R.K. Jones).

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media during the summer range from as low as 59°F (15°C), the minimum temperature needed for infection, to as high as 122° to 131°F (50° to 55°C) at the sun-exposed walls of containers.

Phytophthora dieback (Figures 4, 5, and 6) is a distinct phase of the Phytophthora disease syndrome. The phase on rhododendrons is caused by several species of *Phytophthora* including *P. cactorum*, *P. citricola* and *P. parasitica*. In addition, *P. cinnamomi*, *P. citrophthora*, *P. heveae* and *P. lateralis* have occasionally been isolated from rhododendron tissue with dieback symptoms. Dieback of azaleas is caused primarily by *P. parasitica*.

Losses from both root rot and dieback in the Midwest have risen with the increased use of containers for production. Temperatures are higher in containers than in the field and overwatering is more likely to occur. Losses are highest in containers with poor drainage where there is an excess of soil, sawdust or other fines in the mix. They are lowest when plants are grown in bark mixes with an air volume of 20 to 25 percent.

## Symptoms

**Root rot.** At early stages of root rot in rhododendrons, some dull yellowing and dwarfing of the leaves and retarded shoot growth may occur. Affected leaves commonly roll downward and inward and eventually wilt (Figures 1 and 2). The tips of shoots may die back (Figure 3). Such early symptoms can easily be confused with a nutrient deficiency or drought stress. At first, single branches may wilt during the heat of the day and recover at night.



Figure 3. Greenhouse azalea infected with *Phytophthora cinnamomi* root rot.

Infected roots are reddish brown and brittle. Severe damage to the root system greatly reduces the uptake of water and nutrients resulting in low plant vigor and general plant wilting, dieback and death. When conditions favor disease development, young root rot-susceptible azaleas and rhododendrons may wilt and die within a week to 10 days during the heat of summer. Wilt and dieback symptoms may be rapid if extensive root colonization is followed by hot dry weather. However, symptoms may take several months or years to develop in a cool damp climate and infected but symptomless plants are an important worldwide means of spreading the pathogens. Species and cultivars of rhododendrons and azaleas differ in their susceptibility to *P. cinnamomi* and infected but symptomless (tolerant) plants may be a significant source of disease spread.



Figure 4. Bark has been removed from azalea plants to expose the wood discolored by *Phytophthora cinnamomi* (courtesy D.F. Schoeneweiss).

Root rot may be diagnosed in plants with advanced symptom development by scraping a section of bark from the main stem of the plant near the soil line. A reddish brown to dark brown discoloration of the wood is a symptom of *Phytophthora*. Discoloration of the wood may extend well up into the main stems (Figure 4).

**Dieback.** Circular-like, water-soaked areas that turn chocolate brown within a day or two form on young leaves of rhododendrons and azaleas. Within 3 to 5 days the expanding lesions dry out, become brittle, with infected leaves curling inward and downward but generally remaining attached to the stem.

Infection often grows into the petioles and into stems where it produces a brown, wedge-shaped canker (Figure 5). Entire shoot tips wilt (Figure 6), die back (Figure 7) and turn brown within 5 to 7 days. Young plants with only 4 to 6 inches of new shoot growth may die within a week.

Initial infections develop on expanding rhododendron buds; young leaves and young stems with mature leaves being resistant. The *Phytophthora* fungus may grow from infected stem tissue through petioles into older mature leaves along the midrib and then spread into adjoining tissue to form an extended, V-shaped brown area. Infected mature leaves usually drop off within two weeks. As the stem tissue of rhododendrons matures, disease development slows.

In azaleas both young and mature stems are colonized by dieback fungi, which results in death of entire stems. Young azalea stems commonly develop from axillary buds at the crown. Crown infections are thus much more common on azaleas than on rhododendrons.

## Disease Cycle

*P. cinnamomi* (Figure 8) survives largely as chlamydo-spores and mycelium in infected root and crown tissue and infested host debris in the soil. The fungus does not generally overwinter in Illinois in the absence of host plants. During periods of high soil moisture, sporangia are produced (Figure 8a and b), the contents of which divide (Figure 8c) to form 10 to 30 motile zoospores (Figure 8d). The zoospores swim in water films between soil particles and are attracted by root exudates to nearby host roots where they encyst, germinate, and invade the roots both inter- and intra-cellularly. Zoospores attack roots just behind the root cap. Infection of rhododendron and azalea roots probably occurs when soil temperatures are 59°F (15°C) to 83°F (28°C) with the optimum about 72°F (22°C). Soil water is the critical factor in infection. Young actively growing plants with a high proportion of feeder roots are especially susceptible to *P. cinnamomi* as are roots damaged by high temperatures and severe water or salt stress.

Sporangia are produced in large numbers when the soil is just below saturation and the soil temperature is 59°F (15°C) to 95°F (35°C) with an optimum at 75°F (24°C) at a pH of 5.5. *P. cinnamomi* produces large, non-papillate, non-deciduous sporangia which usually proliferate internally (Figure 8b). The usual temperature range for mycelial growth is between 38° and 93°F (3° to 34°C) with an optimum of 75° to 83°F (24° to 28°C).



Figure 5. *Rhododendron roseum elegans* infected with dieback caused by *Phytophthora citricola* (courtesy R.C. Lambe).



Figure 6. Dieback of azalea caused by *Phytophthora cactorum* (courtesy R.K. Jones).

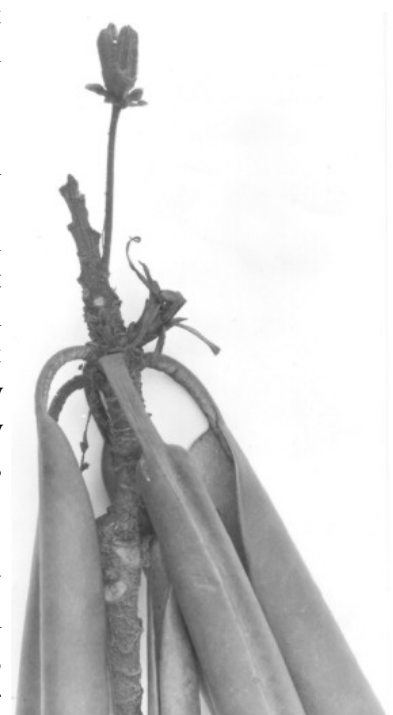


Figure 7. Dieback (*Phytophthora cactorum*) of rhododendron (PA State Univ. Extension Service).

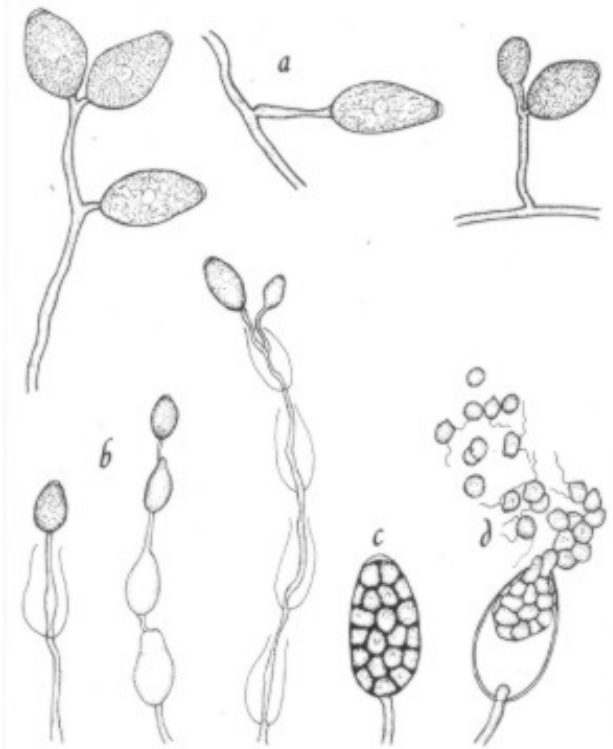


Figure 8. *Phytophthora cinnamomi* as it would appear under a high-power microscope: a, non-papillate sporangia; b, sporangia which have proliferated internally; c, a sporangium where contents have divided up to form zoospores; d, sporangium releasing motile zoospores (drawing by L. Gray).

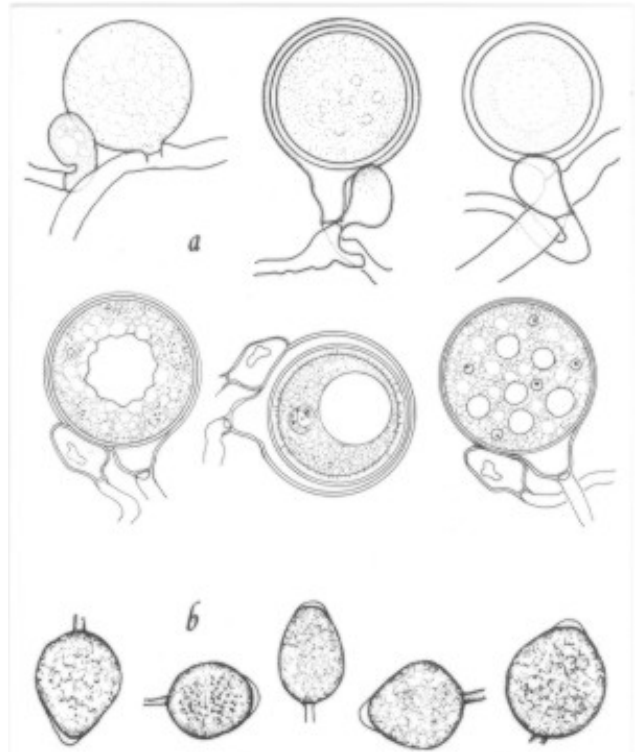


Figure 9. *Phytophthora cactorum* as it would appear under a high-power microscope: a, oospores of varying maturity with attached antheridia; b, sporangia (drawing by L. Gray).

*P. cinnamomi* is a heterothallic species which forms sexual spores (oospores). This may require two mating types (A1 and A2) or an interspecific cross with the opposite mating type of another species such as *P. cryptogea*. The A2 type of mycelium can also produce oospores homothallically if provided with a stimulator substance released by host plant roots. Oospores are rarely produced in nature.

Sporangia and encysted zoospores can survive in moist soil for several weeks but, in the absence of host roots, when soil water potentials and temperatures are sub-optimal for sporangial production, chlamydospores and possible oospores serve as survival propagules. Germination of chlamydospores is stimulated by organic nitrogen and some root exudates, but the conditions that influence oospore germination have not been determined.

Rapid dissemination of *P. cinnamomi* occurs when it is introduced into a new crop of rooted cuttings in irrigation water or with infested “soil” or host debris. It has been isolated from ponds and irrigation water into which surface water has drained from infected rhododendron or other susceptible plantings.

Spread of *P. cinnamomi* from infected to nearby healthy plants is greatest when containers are set on black plastic and the least when they are set on a 2- to 3-inch layer of gravel and/or coarse pine bark. However, splash dispersal from the surface of the container medium to nearby plants also has been observed and could play a role in the spread of the pathogen. After a plant is killed by *P. cinnamomi*, viable propagules of the fungus in the soil and plant debris gradually decline to undetectable levels over a period of 21 months.

All four types of spores produced by *P. cinnamomi* may be involved in infection. Soil moisture plays a key role in the infection process. The most rapid build-up of inoculum is restricted to freestanding water in puddles, saturated soil, the base of containers, and flowing water on the soil surface.

A soil pH of 4.0 controls Phytophthora root rot because sporangium production is inhibited. Such a low pH is not practical in nurseries, however, because plant growth is too slow at this level. The components of container mixes greatly affect the disease cycle of soilborne species of *Phytophthora*. Media with peat as the only component is conducive to infection and disease development. Media amended with tree bark release inhibitors that reduce sporangium production and the release of zoospores. Chlamydospore production and/or survival are apparently not affected by these inhibitors; however, bark-amended media are suppressive to Phytophthora root rot.

*P. cactorum* (Figure 9) survives outside living hosts as oospores (Figure 9a) formed in diseased tissue which remain viable for several years. In free water and a temperature of 50° to 68°F (10° to 20°C) oospores germinate to produce sporangia (Figure 9b) which in turn produce motile zoospores. Zoospores are probably the main infective agents although the germ tubes of sporangia may also initiate infection. A film of water is required for infection to occur. Periods of cloudiness after heavy rainfall or irrigation are ideal for infection.

*P. cactorum* and other Phytophthora dieback fungi are disseminated by mass flow of soil water, irrigation, or by rainsplash, and thus are associated with wet conditions or with poorly drained soils. Invasion is primarily through wounds, unprotected surfaces, and natural openings such as stomata and lenticels. Sporangia may develop in tremendous numbers from diseased tissues and give rise to further cycles of infection.

The disease cycle of Phytophthora dieback is presumed to be the same in azaleas and rhododendrons. It is thought that irrigation or rainfall splashes zoospores and sporangia onto the current season's foliage from the base on which container plants are placed or from the surface of the container medium. In nurseries, the average height of lesions on plants is about a foot above the container base, the range is 6.8 to 24 inches above the base. Fallen, air-dried infected leaves do not serve as a source of inoculum for secondary dissemination or survival of *P. cactorum* or other dieback fungi.

## Control

A comprehensive disease management program is essential to control Phytophthora root rot and dieback. Control measures are divided into those for (a) landscape plantings and (b) propagators and nurserymen. Control includes a series of proper cultural practices combined with disease resistance and the use of fungicides. Control is complicated by the very wide host ranges of the pathogens, the variable and sometimes lengthy period between infection by root rot fungi and the appearance of foliar symptoms, and the longevity of chlamydospores, oospores and mycelium in soil and root debris, often at a considerable depth. Disease control depends on the routine manipulation of many control measures to prevent infection and restrict the spread of disease.

### A. Landscape Plantings

1. Purchase only disease-free, balled and burlapped (B&B) or container-grown rhododendrons and azaleas from a reputable nursery where strict sanitation-indexing production procedures (see below) for macropropagation have been followed. Be sure the plants have white, healthy

rootlets and good foliage color free of leaf lesions.

2. Plant in sites amply protected from wind and direct afternoon sun. Avoid southern exposure. These plants do best on the east or north sides around buildings. In open areas they prefer filtered shade or alternating sun and shade as found under tall, deep-rooted trees such as oaks, hickories, pines, and hemlocks. Locate plants where the site does not dry out too quickly and is well-drained, where there is adequate air circulation, and away from competing, shallow-rooted trees such as maples, elms, poplars, and birches.

Avoid planting in unusually narrow areas between a house foundation and a paved walk; frost pockets, such as a closed valley or depressions in which cold air settles; areas where water may stand for several days injuring or killing the roots; locations where they will be exposed to strong winter sunshine and subject to sudden temperature fluctuations such as sun to shade in late afternoon.

Space the plants far enough apart from other plants or building so they will not be crowded when mature. A good plan is to place small azaleas two feet apart. After 3 or 4 years, when they start to crowd each other, remove alternate plants and replant in another location, thus giving the remaining plants room to develop.

3. Rhododendrons and azaleas require special soils for their best growth. Light, porous, well-drained soils with an abundance of organic matter is a must for satisfactory growth. In addition, the soil must be acid (pH 4.5 to 5.5). Poor growth, yellowish foliage—often due to iron chlorosis—and dying of branches will occur if the soil is not sufficiently acid. For poorly aerated, heavy clay soils use a mixture of 50 percent leaf mold or peat moss, 25 percent coarse sand, and 25 percent soil. In such soils drainage should be supplied by drain tiles or by placing a layer of crushed stones or cinders under at least two feet of well-prepared soil mix in which the plants are set. Another solution is to construct raised beds that will provide good drainage.

If the natural soil is alkaline, this can be corrected by adding acidifying materials. Check with your University of Illinois Extension horticulturist or local Extension office on what to use and how it should be applied. Iron or ammonium sulfate are good choices. For more slowly acidifying agents, spent tan-bark, well-rotted hardwood sawdust, and rotted oak leaves can be used. These materials also increase the organic matter in the soil which tends to maintain a constant supply of moisture for roots.

4. Apply a 3- to 6-inch mulch over the soil surface after planting. Use tree bark, weathered wood chips or shavings, acid leaf mold, or weathered sawdust. Then cover the surface with oak leaves or pine needles when available. Oak leaves or pine needles may be used alone to a 3- to 6-inch depth. Add mulch when growth has hardened in the fall, after deciduous plants have dropped most of their leaves.

Mulching will insulate the soil from sudden temperature freezes and reduce the depth to which freezing occurs. Leave mulches in place during the growing season for insulation, moisture-retention, and to maintain more favorable conditions in the root zone. Mulches tend to decompose rapidly in fertile soils, therefore add new mulch each autumn. Use 10 to 12 inches of dry leaf mulch (oak is preferable) or enough pine needles to maintain at least a 3-inch layer.

5. Rhododendrons and azaleas are shallow rooted and ample moisture must be maintained about

their roots at all times. In late November water the ground thoroughly to prevent its drying out during winter.

6. Fertilize annually according to recommendations of Extension horticulturists or your nearest Extension office. Nitrogen in the ammonium form, such as ammonium sulfate, is preferred rather than the nitrate form. Young rhododendron and azalea leaves with 1.8 to 2.5 percent nitrogen are highly susceptible to infection by dieback fungi. Those with 0.7 percent nitrogen have fewer and smaller lesions that do not expand.
7. Cultivars in 10 hybrid azalea groups vary from highly resistant to highly susceptible to *P. cinnamomi*. The most resistant cultivars in a large test were Formosa, Fakir and Corrine Murrah. The Indica hybrids as a group are the most resistant and Carla hybrids the most susceptible. The azalea species *Rhododendron poukanense* has good resistance and cold hardiness and is commercially acceptable.

The following azalea cultivars are reported as having resistance:

Curlin hybrid: Fred Cochran;  
Glenn Dale hybrids: Fakir, Glacier, Merlin, Polar Seas;  
Gable hybrid: Rose Greeley;  
Kurume hybrid: Morning Glow; and  
Satsuka cultivars: Higasa, Shin-ku-gen, Pink Gumpo, and Eiken.

The resistance of azaleas and rhododendrons can be greatly reduced by moisture stress caused by too much or too little water. Most rhododendron hybrids and the native rhododendron species, *R. maximum*, are susceptible to Phytophthora dieback. In a survey of nurseries, this disease was greatest in the cultivars Chionoides White, Catawbiense Album and Nova Zembla and lowest in Roseum Elegans, Scintillation, and PJM.

8. Where Phytophthora root rot and dieback have been a problem in the past, or are expected to cause injury, apply a **preventive** fungicide as a spray, or drench around plants to saturate the soil. Repeat at 2- to 12-week intervals in spring and autumn; or blend granules into the soil mix just before planting. There are **no** therapeutic fungicides. Infected nursery stock may eventually become diseased in the landscape even if it is repeatedly treated. When using a fungicide, carefully follow label directions. Recommended fungicides to control Phytophthora root rot and dieback are given in Illinois Homeowners' Guide to Pest Management. This circular is revised annually.

## **B. Propagators and Nurserymen**

1. Nursery stock should be grown under high standards of sanitation using a clean (chlorinated) water supply. Propagate only from cuttings taken from disease-free mother plants. Take cuttings high on stock plants where soil has not splashed. This avoids introducing root rot and dieback pathogens to the rooting bed. Soil particles should not adhere to the leaves or stems of cuttings. Domestic or foreign imported stock should be segregated in the nursery and preferably grown in containers for several months to be sure the plants are healthy and free of infection. Potting compost and propagation benches, beds, containers, and tools should be steam-pasteurized (air-steam mixtures at 160°F for an hour). Field beds may be fumigated with methyl bromide, methyl bromide-chloropicrin mixtures, Vorlex or Vapam **prior to planting**. These

chemicals are limited to the depth of fumigant penetration. They are highly toxic materials, many of which are restricted, and should be carefully applied, strictly following the manufacturer's directions. Soils usually become reinvaded within several months of fumigation and then root rot and dieback progress as they did before treatment. In nurseries, infested soil is often fumigated with methyl bromide or a methyl bromide-chloropicrin mixture and thereafter treated with organic amendments to prevent or reduce recolonization of the soil by species of *Phytophthora*. This practice induces suppressiveness of the soil.

In the propagation house, direct contact of potting medium with the ground should be avoided by using screen-bottom benches. Prior to filling benches and sticking cuttings, all wood surfaces should be scrubbed down with a disinfectant such as fresh liquid household bleach (1 part bleach in 5 parts of clean tap water). Containers used in potting operations should be new or fumigated prior to reuse and never stored directly on the ground.

2. A well-drained potting mix is essential. A major component of nursery potting media is composted hardwood bark or pine bark. Certain inhibitory chemicals that suppress root rot fungi are formed during the composting of hardwood bark. Apparently pine bark is suppressive to root rot fungi because of the excellent drainage. In general, avoid soil since it retains water too long, may contain spores of *Phytophthora*, and makes containers too heavy to handle conveniently. When soil is used as a component of the potting mix, it should be steamed or fumigated prior to use. Peat moss or weathered sawdust alone should also be avoided. Media prepared with very fine bark particles can also be conducive to disease. The potting medium should contain 10 to 15 percent air-filled pore space. To assure adequate drainage the water percolation rate of potting media must remain at an inch per minute throughout the production cycle.
3. It is important to place container-grown plants on a well-drained base such as 3 to 4 inches of gravel, a similar neutral aggregate or pine bark to prevent splash dispersal of zoospores and sporangia. Regulate the irrigation system to avoid the formation of puddles or periodic overwatering.

Container areas should be graded prior to use to provide surface water drainage away from the growing area. Locate water control ditches throughout the nursery so run-off water during irrigation or heavy rainstorms will be channeled away from container areas, potting media, storage piles, and other potting supply areas. Installing concrete pads for storing container media and pots, mixing and potting (canning) operations is a good investment. This protects against introducing root rot and dieback fungi accidentally into the nursery operation.

Host debris, such as prunings and fallen infected leaves, should be removed from the production area between crops to reduce the survival of *Phytophthora*. Group plants in the nursery by container size and water requirements to avoid the danger of overwatering. Commercially-available irriometers can be used to monitor the soil-water status so water is applied only when needed.

4. Field plants should be grown in well-drained soil. Routinely inspect plantings and either destroy infected plants (with root rot) or skillfully prune and burn shoots with dieback. Prune diseased tips well below the cankered and shriveled part. Prevent the movement of *Phytophthora*-infested soil on footwear, tools and equipment. In infested field soil the incidence of *P. cinnamomi* can be reduced, if not eliminated, by cropping with a nonsusceptible host, leaving the land fallow for at least four years or incorporating organic nitrogen into the soil.



5. Fertilize to avoid excessive concentrations of nitrogen in the foliage.
6. If dieback has been a problem, lessen shade if possible and increase air movement.
7. When possible, grow resistant species and cultivars of azaleas as given under A7, Landscape Plantings.
8. Preventive fungicides active against species of *Phytophthora* and *Pythium* can be applied to healthy, container-grown plants as sprays, drenches to the soil surface, or by incorporating granules into the potting medium at canning.

In all methods of application the fungicide(s) is/are effective only when: (1) it is applied **prior** to infection, and (2) concentration of the fungicide remains at or above the effective rate. This means that repeated applications will be needed, usually at 2- to 8-week intervals, throughout the growing season. Emphasis, however, should **not** be placed on fungicides but on correct cultural practices. The use of fungicides in the nursery is important to prevent the spread of *Phytophthora* from infected to healthy plants. If root rot or dieback symptoms should develop on a few plants in a container block, applications of fungicide to all plants in the block is recommended to prevent further spread to healthy plants. Applied as eradicants, once plants are infected, fungicides will arrest but generally **not** kill the fungi or fungi in infected roots and soil. Suggested fungicides to control *Phytophthora* root rot or wilt and dieback are given in Illinois Homeowners' Guide to Pest Management, which is revised annually.