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Diseases of Leatherleaf Fern Caused by *Calonectria* and *Cylindrocladium* Species

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Typical leaf spots on leatherleaf fern caused by *Calonectria theae*. Leaf spots are tan in the center and have brown, diffuse edges. Small spots are completely brown or tan.

Introduction

Leatherleaf fern, *Rumohra adiantiformis* (G. Forst.) Ching, is the most widely used greenery in the florist industry today. The dark green, versatile, long-lasting fronds of leatherleaf fern have made it indispensable to many floral designers across the United States, where the estimated wholesale value of cut fern fronds exceeds $60 million per year.

Although a multitude of other types of greenery are available in Hawaii, the leatherleaf fern is heavily used. Local production of cut fern is minimal, and most of the fern used by florists is imported. Local nurseries produce potted ferns for use as indoor greens or as landscape components.

Only a few diseases are known to plague leatherleaf fern in Hawaii. Fungal pathogens that have been associated with foliar and root diseases are *Calonectria theae* C. A. Loos, *Cylindrocladium pteridis* F. A. Wolf, *Rhizoctonia* species, *Cercospora* species, and *Pythium* species. The lesion nematode, *Pratylenchus*, attacks roots of this fern in Hawaii. In Florida, *Cylindrocladium floridanum* Sobers & C. P. Seymour, *C. heptaseptatum* Sobers, Alfieri & J. F. Knauss, *C. pteridis*, and *C. scoparium* Morg. have been reported as pathogens of leatherleaf fern. *Rhizoctonia* spp. and several other fungi are also associated with diseased ferns.

Leaf spots on leatherleaf fern caused by *Cylindrocladium heptaseptatum*. Leaf spots that resemble eyes are also formed when a dark center is surrounded by tan tissue.

Advanced rots and blights of leatherleaf fern caused by *Calonectria theae*.

In Hawaii, imported fern fronds often originate from Florida. The fronds are arranged in tightly packed bunches of 15 to 25 leaves, depending on the grade and producer. The bunches, usually 25 to 40 per case, arrive in waxed boxes lined with a plastic wrap that retains moisture during transit. These cases are sent to Hawaii by air, which subjects ferns to varying ambient temperatures during transit. These temperatures are higher and generally vary more widely for air transportation compared to temperatures in refrigerated containers. Postharvest rots commonly develop on imported ferns during certain periods of the year, and the fronds are characteristically brown and water-soaked. Leaf decay frequently begins within bunches and spreads rapidly through the case. *Cylindrocladium heptaseptatum* and *Rhizoctonia solani* have been recovered from these diseased leaves. In Europe, postharvest rots of ferns from Florida were shown to be caused by *C. heptaseptatum*, *C. pteridis*, and a *Rhizoctonia* species.

Research on the pathology of leatherleaf fern was initiated in Hawaii recently, and this paper reports the finding of diseases caused by the fungi *Calonectria* and *Cylindrocladium*.

Symptoms

Leaf spots caused by *Calonectria theae* begin as small, dark, water-soaked spots. After a few days, these spots form tan to light brown rots, 2 to 5 mm long, with a

Wilted leatherleaf fern; leaf stem (petiole) infections and leaf spots caused by *Cylindrocladium heptaseptatum* result in frond wilt.

darker border around the rotted tissue. Many small leaflets are killed and larger areas of the leaf are diseased as rotted areas coalesce or merge (Fig. 1). Rots are 5 to 11 mm long (3⁄16 to 7⁄16 inch), and numerous spots of various sizes may cover each leaf. On mature fronds, rots are dark brown, grayish-brown, or rusty brown, while rots of young fronds are tan to slightly grayish-brown. Yellowing is also associated with the infection of younger fronds. After a week, some of the tan spots with dark edges develop dark brown centers, giving the spots the appearance of eye-spots (Fig. 2). As rots continue to expand, blights or large spots develop (Fig. 3), and parts of the leaf are eventually killed (Fig. 4). Wilted or dried leaves also occur in advanced stages (Fig. 5). Infections of the midrib cause leaf loss in potted plants. Complete loss of the entire leaf is less frequent in mature fields, but leaf spots reduce yield and quality. Postharvest rots can also develop when infected fronds are stored.

Petiole or leaf stem infections are approximately 15 to 40 mm (about ½ to 1½ inches) long or more and girdle the petiole, causing fronds to wilt (Fig. 6). Alternatively, petioles are weakened by these lesions and can break in pots, in the field, or during harvest. Infections of the midrib also cause parts of the fronds to bend, wilt, and die.

Infected roots are difficult to recognize but generally are darker brown than healthy roots. Healthy roots have succulent, greenish-yellow tips. These are missing in diseased roots, and the entire root system is brittle and tears apart with ease. The rhizome (underground stem) of the fern is covered with fuzzy, dark brown plant hairs and is also attacked by fungal pathogens. Spots and rots are difficult to see but are characterized by soft, dark brown areas. Rhizomes that are completely diseased will break off when slightly bent or lightly pressured.

A few of the isolates (strains) of *Calonectria theae* among those that we examined were weaker, and only a few small spots developed on ferns inoculated with these isolates (Fig. 7).

The symptoms caused by *Calonectria theae* and *Cylindrocladium pteridis* on leatherleaf fern are similar, while those caused by *C. heptaseptatum* are slightly more severe.

Leatherleaf fern plants severely diseased by *Cylindrocladium heptaseptatum.*

Disease spread

The spores of *Calonectria theae* and the two *Cylindrocladium* species are microscopic in size, long and narrow (cylindrical) in shape, and are produced in large numbers on the surface of diseased leaves and stems. Splashing water from rain or irrigation spreads pathogen spores in the field or greenhouse. Snails, slugs, insects, mice, toads, and other pests also move these spores. Major distribution of these fungi occurs when diseased plants are moved from one location to another. When infected plants are planted in new fields, the disease develops on these plants and the fungi become established in the soil. *Calonectria* is difficult to eradicate from soil once it has contaminated a location or field.

Both *Calonectria* and *Cylindrocladium* survive in infected rhizomes or dead tissue. These pathogens also produce tiny sclerotia that survive in soil for long periods without the host.

Calonectria theae also produces a second type of spore called the ascospore. Ascospores are produced in very small, red, fungal fruiting bodies called perithecia. When mature, the ascospores are forcibly discharged into the air from perithecia and are carried by air currents. The potential for disease spread by *Calonectria* is thus much greater than for fungi that are spread by splashing spores. Red perithecia are occasionally seen on rotting tissue in moist environments. However, other fungi that do not cause disease (e.g., non-pathogens or saprophytes) may produce red perithecia. Thus, observation of these red perithecia is a clue to pathogen presence but must be checked microscopically to accurately identify the pathogen or causal agent of disease.

Control

Moisture control. Moisture favors disease development in this crop. Cultural practices that reduce extended periods of high moisture will reduce disease levels. These include increasing the spacing between plants to de-

Rots of the midrib and petiole (leaf stem) caused by *Cylindrocladium heptaseptatum.*

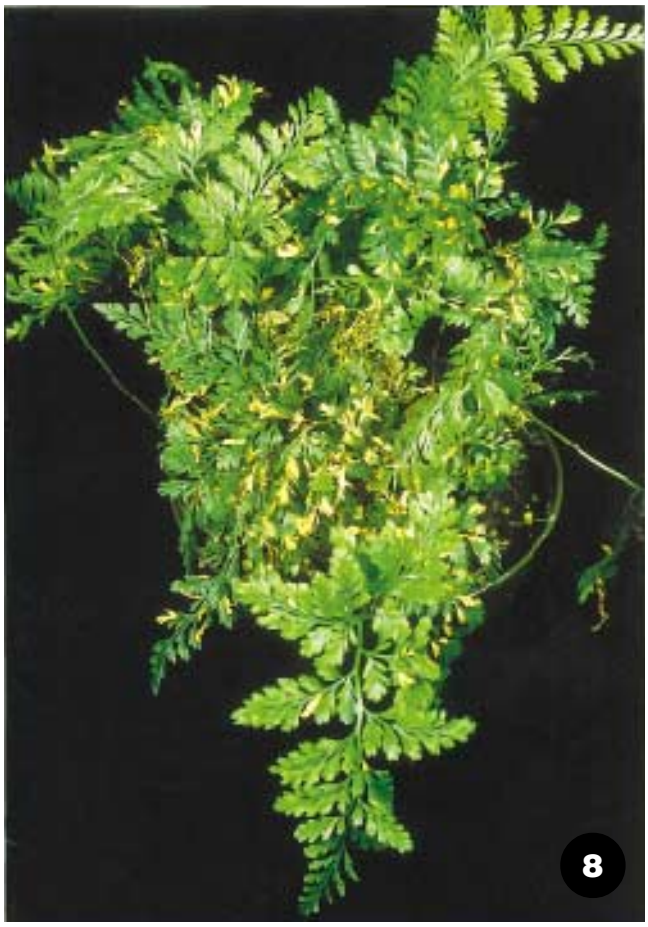
Small yellow to tan spots are formed by weak isolates of *Calonectria theae.*

crease humidity; irrigating the potting media or soil, with minimal wetting of the foliage; watering in the morning rather than in the late afternoon to reduce leaf-wetness at night; increasing air movement in the field, greenhouse, or landscape by removing weeds and/or trees in surrounding areas; and removing older, damaged, or dead leaves.

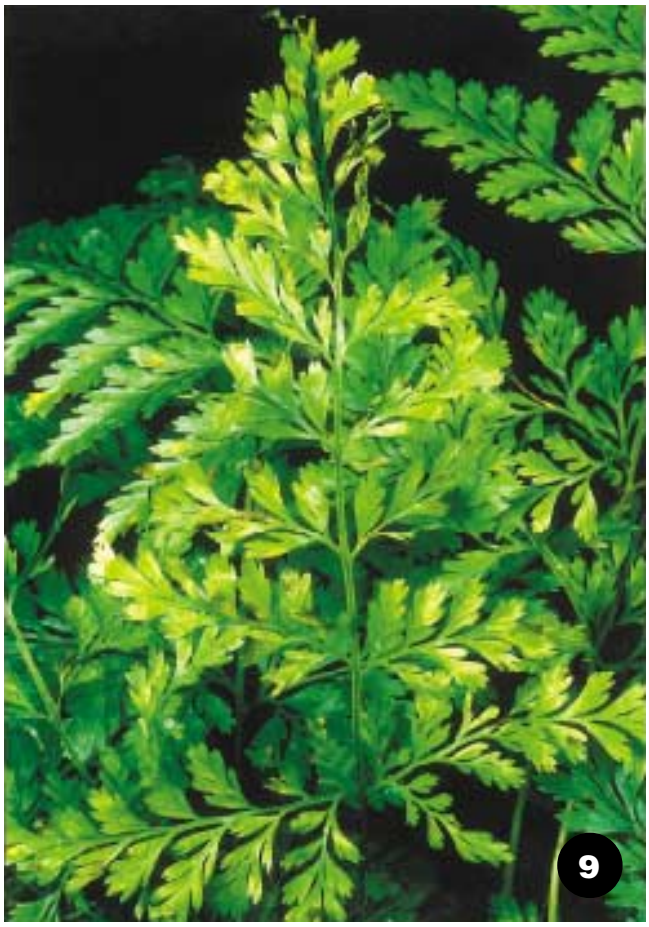
Fern growth benefits from the higher humidities of the tropics. However, low light levels and excessive humidity result in weak fronds with thin leaf blades. These succulent leaves are highly susceptible to infection by pathogens, and disease development is rapid once infection occurs.

Sanitation. Since new leaf spots are caused by the movement of fungal spores and their subsequent growth, it is important to remove all diseased leaves, especially those that have fallen to the ground. Leaves with spots and rotted plant sections should be removed from potted plants. Diseased leaves, rhizomes, and roots should be collected and removed from the nursery. By keeping diseased plants, the pathogen is maintained at the nursery and will produce new spores to continue the disease cycle.

While fungal spores are commonly spread to healthy plants by wind or splashing water, gardeners and nursery workers also can carry spores by handling infected plants. Small animals, insects, and slugs also move pathogens. Insect populations must be controlled, and slugs or snails must be eliminated. Entry of mice and other small animals must be prevented by screening or



Leaf spots and blight of *Davallia* species caused by *Cylindrocladium heptaseptatum*.



Leaf spots on *Davallia* species of leatherleaf fern caused by *Cylindrocladium heptaseptatum*; close-up of young frond.

other barriers. Used pots, tags, trays, irrigation spigots, and potting soil will also harbor the pathogen. Discard potting soil from diseased plants and sterilize all pots, trays and other products if they are reused. A 10% solution of household bleach will effectively sterilize washed plastic pots, tags, trays, etc. Make the 10% solution daily, add a few drops of detergent to remove air bubbles on the surface of pots, soak washed plastics for at least 10 minutes (making sure that all surfaces are exposed to the liquid), and change the bleach solution often. For example, with a typical 5-gallon bucket of 10% bleach, nearly 1000 washed 4-inch pots can be surface-sterilized. However, if pots are not washed well and have roots or media adhering to them, only a fraction of that number will be sterilized. The activity of the bleaching solution is decreased by contact with organic matter. The presence of a chlorine odor does not mean that the solution is still effective.

Chemical control. Fungicides such as Dithane M-45 will reduce disease levels. Good coverage of the leaf surface with contact fungicides such as Dithane M-45 is important for disease control. Dithane M-45 and many other fungicides inhibit fungal spore germination and growth by direct contact between the fungicide and the fungus. Systemic fungicides such as Cleary 3336 also can be used. Most systemic fungicides move in the plant

in an upward and outward pattern. Because of this directional movement in the vascular system of the plant, systemic fungicides tend to concentrate at leaf edges and tips. In order to maintain adequate protection, follow-up applications are necessary. In addition, systemic fungicides must be rotated with other fungicides such as Dithane M-45 to prevent the selection of strains of the pathogen that are resistant to the fungicide. Strains of *Cylindrocladium heptaseptatum* that are resistant to methyl thiophanate fungicides are already known to exist in Hawaii and Florida.

For fields of leatherleaf fern, most of the above recommendations also apply. Growers should perform the following disease management procedures: reduce humidity by removing old or damaged leaves and all weeds or shrubs surrounding the greenhouse; encourage good air circulation in the field; apply water to rhizomes/roots and not the entire plant; irrigate in the morning and not in the evening, to keep leaves dry for as long as posssible; remove all diseased leaves, stems, and severely rotted rhizomes from the field; apply fungicides as needed; survey the field frequently and remove all new rots as soon as they occur; provide adequate light. A light application of compost can aid the recovery of severely diseased plantings of ferns.

These cultural methods (moisture control, sanitation, and good cultural practices), with supplemental applications of Dithane M-45 or other contact fungicides, are recommended approaches to disease control. The best approach for new growers is to prevent disease by avoiding and excluding pathogens at all stages of plant growth and production.

Wholesalers or retailers who deal with cut ferns can reduce postharvest losses by unpacking bunches and examining each leaf carefully. All rots, spots, and large water-soaked areas need to be removed. These fungi continue to grow at 50˚F in infected leaves. Leaves should be rebunched and repacked with newspaper or some other type of absorbent material to reduce disease spread and to absorb excess moisture in the box. Growers or shippers with diseased plant materials should be notified so preharvest and field disease control measures can be implemented.

Other hosts

Calonectria theae causes leaf spots of ohia (*Metrosideros collinus* (J. R. Forster) A. Gray), white bird-of-paradise (*Strelitzia nicolai* Regel & Korn), and sentry palm (*Howea forsteriana* (C. Moore & F. v. Muell.) Becc.). The petiole and sheath of white bird-of-paradise and sentry palm are also spotted, and severe disease of ohia causes defoliation (loss of leaves). Early tests indicate that *Calonectria theae* collected from diseased ohia, white bird-of-paradise, and sentry palm will also infect leatherleaf fern. These plants should be checked carefully for disease, otherwise the pathogen may spread from one type of plant to the next.

Squirrel's-foot fern (*Davallia trichomanoides* Blume), locally sold as rabbit's-foot fern, was also severely diseased in our experiments by all three pathogens (Figs. 8 and 9). Australian tree fern (*Cyanthea cooperi* (F. v. Muell.) Domin.) and palapalai (*Microlepia* species), were tolerant of *C. theae*, and only small black spots were formed following inoculation.