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CYLINDROCLADIUM POSTHARVEST DECAY ON FLORIDA LEATHERLEAF FERN ARRIVING IN EUROPE[1,2]

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Abstract. **Florida leatherleaf fern** (Rumohra adiantiformis **(G. Forst.) Ching) was inoculated with** Cylindrocladium heptaseptatum **Sobers, Alfieri and Knauss and subjected to varying postharvest handling procedures in simulated and actual in-transit tests.**

In a simulated transit test, freshly harvested fern that was inoculated and held at 21°C for 48 hrs became infected. Inoculated fern dipped in benomyl or chlorothalonil and held at 21°C *did not* decay. Benomyl or chlorothalonil treatments on infected fern did not control C. heptaseptatum.

In an in-transit test, a fungicide mixture (benomyl and chlorothalonil) applied as a postharvest dip controlled decay; but, a delayed fungicide treatment to inoculated fern did not control decay as a dip immediately after harvest. In a second in-transit test, inoculated fern were held at 21°C for varying intervals and sent to Rotterdam. Inoculated fern held at 21°C at increasing intervals arrived in Rotterdam with increased levels of decay. Control (noninoculated) fern held at 21°C for 48 hrs and subsequently shipped to Rotterdam arrived free of decay. It was concluded Cylindrocladium **postharvest decay in leatherleaf fern can be controlled by maintaining good disease control in the nursery, using a fungicidal dip immediately after harvest and rapidly cooling and maintaining low temperature immediately after harvest and during the transit period.**

In the past few years, the quantity of Florida leatherleaf fern shipped to Western Europe has increased dramatically. In 1979-80, approximately 31% of the Florida crop was exported (1). Leatherleaf fern is probably the singlemost important ornamental crop exported from the U.S. If transit temperatures are adequately maintained (e.g. 0.6-4.4°C) and air flow is not restricted in mobile containers, fern normally arrives in Western Europe in good to excellent condition (4, 5). There are a few postharvest problems with leatherleaf fern. Miller *et al.* (5) reported 2 problems (chlorosis and blackening of fronds) occurring during the marketing and transit of leatherleaf fern. They related both disorders to poor temperature control. Chlorosis was associated with excessively high temperatures; while, blackening of fronds was due to extremely low (freezing) temperatures. Marousky and de Wildt (2, 3) reported a postharvest decay on Florida leatherleaf fern arriving in Western Europe. Principal symptom was a brown-bronze decay occurring at the margins and apices of fronds. In some instances, entire bunches of fronds were decayed. The fungi isolated from decaying tissue includes a species of *Rhizoctonia, Cylindrocladium pteridis* Wolf (9) and *C. heptaseptatum* Sobers, Alfieri and Knauss (8). This was the first time *C. heptaseptatum* was reported in Florida leatherleaf fern arriving in Western Europe. Schickedanz (6) reported finding *C. macrosporum* in Florida leatherleaf fern arriving in Germany. Sobers (7) reported that *C. macrosporum* is synomymous to *C. pteridis*. The pathogenicity and some of the methods for control of *C. pteridis* and *C. heptaseptatum* have been elucidated in the laboratory (2, 3); but, methods to control decay using practical postharvest handling techniques have not been published. The purpose of this paper is to report on the control of postharvest decay in cut leatherleaf fern caused by *Cylindrocladium heptaseptatum* during simulated and actual handling and transit tests.

Materials and Methods

Simulated test. The *C. heptaseptatum* used was initially isolated from decaying tissue in Florida leatherleaf fern arriving in Rotterdam (2, 3). The fungus was grown on PDA in Petri plates. Each surface of a sporulating culture was rubbed lightly with a sterile loop and rinsed with 100 ml of sterile water. Leaflets (90 mm) were inoculated by dipping in the conidial suspension (2700 conidia/ml). Noninoculated (control) leaflets were dipped in sterile water. Inoculated leaflets were dipped in water, 0.35 g benomyl/liter (as Benlate WP) or 1.0 g chlorothalonil/liter (as Daconil 75 WP) immediately or 24 hours after inoculation. Control (noninoculated) leaflets were also dipped in water or the fungicidal suspensions. Control (noninoculated) and inoculated leaflets were dipped in different fungicidal suspensions to prevent any cross contamination. All leaflets were held at 24°C for 1 week. Numbers of lesions were counted after 2 days and percent of leaflet area decayed was estimated after 7 days.

Transit tests. Ferns were harvested from nurseries in the Zellwood, FL, area, bunched and transported to the ARS laboratory in Orlando. No fungicides were used on the ferns during this period. Individual bunches were dipped in an aqueous conidial suspension of *C. heptaseptatum* or in water (control). The conidial suspension was prepared as indicated above except that 500 ml of water was used to rinse each Petri plate. Fifteen plates were used to make the inoculum. Immediately, 4 hours, and 24 hours after inoculation, bunches of fern were dipped (30 sec) in a fungicidal suspension consisting of a mixture of 0.35 g benomyl and 1.0 g chlorothalonil/liter of water (supplied as Benlate 50 WP and Daconil 75 WP, respectively). Control (noninoculated) fern was also dipped in the fungicide mixture.

[1]Trade names and company names are used in this publication solely for the purpose of providing specific information. Their mention does not constitute a guarantee or warranty of a product by the U.S. Department of Agriculture or an implication of product registration under FIFRA as amended.

[2]The authors gratefully acknowledge the cooperation of The Netherlands Plant Protection Service for permission to carry on the in-transit tests.

All bunches were held under polyethylene sheeting at 21°C for 48 hr. Subsequently, each bunch was placed in a plastic bag and packed in waxed corrugated fiberboard boxes, 75 cm long x 35 cm high x 23 cm wide (30 in x 14 in x 9 in) lined with polyethylene sheeting. Ryan thermographs were placed in the center of each carton. The packed box was held at 1.1°C. The fern was transported to a commercial shipper and loaded into a refrigerated mobile container with the thermostat set at 2.7°C (37°F) and shipped to Rotterdam. Overland travel, sea voyage and the unloading in Rotterdam required 15 days. One lot of similarly treated fern as those sent to Rotterdam was held in Orlando at 2.2°C (36°F) and 85-90% RH. Disease severity was based on the percent of leaf area decayed on individual fronds; 1 = no decay; 2 = little decay; 1-2% of frond decayed; 3 = 3-15% of frond decayed; 4 = 16-50% of frond decay; 5 = over 50% of frond decayed. All fronds in a bunch were evaluated and an average disease severity rating was obtained.

Fern was harvested, handled and transported to the Orlando laboratory as in the previous test. Bunches of fern were dipped in water or a conidial suspension of *C. heptaseptatum*. Fern (inoculated and noninoculated) were placed in plastic polyethylene bags and held at 21°C for 0, 8, 24, 48 hours. Fern was held at 2.2°C when not exposed to 21°C. The maximum holding period for the various temperature combinations was 48 hours. Fern was subsequently packed and shipped as in the previous experiments. It required 13 days for fern to reach Rotterdam. Comparably treated fern were held in simulated shipping conditions in Orlando for 10 days. Ferns were evaluated for disease severity using the above schedule.

Results

Leaflets inoculated with *C. heptaseptatum* and not treated with benomyl or chlorothalonil became infected (Table 1). Initial infections appeared as lesions which eventually coalesced and in 1 week over 75% of the leaflet surface was decayed. Benomyl and chlorothalonil effectively controlled decay when the leaflets were dipped after inoculation. Benomyl was slightly more effective than chlorothalonil when fungicides were used on infected leaflets. Noninoculated (control) leaflets dipped in benomyl or chlorothalonil were not infected. These leaflets showed no visible symptoms of deterioration after 1 week at 24°C.

Inoculated fern shipped to Rotterdam arrived severely decayed if they had not been dipped in fungicides (Table 2). Noninoculated (control) leaflets, with or without fungicidal treatments, arrived in Rotterdam free of decay. The benomyl-chlorothalonil provided good disease control when leaflets were dipped up to 4 hours after inoculation. The mixture did not completely control decay when leaflets were dipped 24 hours after inoculation but disease severity was greatly reduced compared to no dip. Disease severity on fern held in simulated transit conditions in Orlando was similar to disease severity on fern shipped to Rotterdam. During transit, temperature in boxes was maintained close to mobile container thermostat setting of 2.7°C (*i.e.* 37 ± 3°F). *C. heptaseptatum* colonies were reisolated from test ferns to confirm pathogenesis.

Inoculated fern held at 21°C for 24 or 48 hours prior to shipping arrived with decay (Table 3). Noninoculated (control) fern held at 21°C for 0 to 8 hours arrived free of decay. Noninoculated (control) fern held at 21°C for 24 and 48 hours had some injury (chlorosis) but *C. heptaseptatum* was not isolated from any fronds. Inoculated fern held at 21°C for 0 to 8 hours had a few lesions present and *C. heptaseptatum* was isolated from tissue.

Table 2. Influence of *Cylindrocladium heptaseptatum* and a fungicide on severity of infection in leatherleaf fern shipped to Rotterdam or held in simulated conditions in Orlando.

Treatment	Benomyl + chlorothalonil dip treatment	Disease severity[z] Rotterdam after 15 days	Disease severity[z] Orlando after 14 days
Control (noninoculated)	none	1.0 c[y]	1.0 c
Control (noninoculated)	after harvest	1.0 c	1.0 c
Inoculated	none	5.0 a	5.0 a
Inoculated	immediately	1.0 c	1.2 c
Inoculated	4 hr after inoculation	1.1 c	1.2 c
Inoculated	24 hr after inoculation	1.5 b	1.8 b

[z]1 = no disease and 5 = >50% of frond area decayed.
[y]Means in a column followed by different letters are significantly different at the 5% level.

Table 3. Influence of *Cylindrocladium heptaseptatum* and time at 21°C during handling on disease severity in leatherleaf fern shipped to Rotterdam or held in simulated conditions in Orlando.

Treatment	Time at 21°C prior to shipping[y]	Disease severity[z] Rotterdam	Disease severity[z] Orlando
Control (noninoculated)	0	1.0[x]	1.1[x]
Control (noninoculated)	8 hrs	1.0	1.2
Control (noninoculated)	24 hrs	1.2	1.3
Control (noninoculated)	48 hrs	1.2	1.4
Inoculated	0	1.2	1.2
Inoculated	8 hrs	1.2	1.3
Inoculated	24 hrs	1.7	2.4
Inoculated	48 hrs	2.9	3.8

[z]1 = no disease and 5 = >50% of frond area decayed.
[y]Held at 2.2°C when not at 21°C.
[x]Inoculation (I), time (T) and I x T interaction significant at the 1% level.

Table 1. Influence of *Cylindrocladium heptaseptatum* and fungicides on the number of lesions after 2 days and percent decay after 7 days on leatherleaf fern leaflets held at 24°C.

Treatments	Fungicide	Fungicide applied	No. of lesions/leaflet after 2 days	Percent area of leaflet decayed after 7 days
Control (noninoculated)	water	at harvest	0	0
Control (noninoculated)	benomyl	at harvest	0	0
Control (noninoculated)	chlorothalonil	at harvest	0	0
Inoculated	water	after inoculation	7.3	75.
Inoculated	benomyl	after inoculation	0	0
Inoculated	chlorothalonil	after inoculation	0	0
Inoculated	water	24 hr after inoculation	7.5	88.
Inoculated	benomyl	24 hr after inoculation	0.3	<5.
Inoculated	chlorothalonil	24 hr after inoculation	1.0	19.

Disease severity on fern held in simulated transit conditions in Orlando were similar to fern arriving in Rotterdam. However, inoculated fern held at 21°C for 24 and 48 hours and subsequently held in simulated shipping conditions in Orlando had a higher disease level than similarly handled fern shipped to Rotterdam. During transit, temperatures in cartons were maintained close to mobile container thermostat setting of 2.7°C (*i.e.* 37 ± 3°F).

Discussion

Cylindrocladium heptaseptatum caused decay in cut fronds in simulated and actual handling and in-transit tests (Table 1, 2, and 3). Typical postharvest decay symptoms were similar to those reported earlier (2, 3). Initial infections were small irregular circular brown lesions visible 2 days after inoculation. The lesions enlarged, coalesced and the affected decayed area became bronze-brown with a water soaked appearance. The latter phase (bronze-browning) was the one most frequently observed in Rotterdam.

A postharvest fungicidal (benomyl and chlorothalonil) treatment controlled decay caused by *C. heptaseptatum* but a delay in fungicidal treatment to inoculated infected fern did not totally control decay. These data suggest that fern inoculated naturally with *C. heptaseptatum* in the nursery could develop postharvest decay even though they are treated (dipped) with a postharvest fungicide. Hence, additional research is needed to develop improved controls for *C. heptaseptatum* in the production nursery. We have observed decay in several containers of commercial fern arriving in Rotterdam (2). In 2 instances we have found *C. heptaseptatum* in the nurseries supplying the fern. Both nurseries used a postharvest fungicidal dip as part of their routine handling and packing procedures. *C. heptaseptatum* was originally reported in Honduras (8); but, this is the first instance it is reported in Florida.

Warm temperature (*i.e.* 21°C) after harvest is an environmental prerequisite for infection by *C. heptaseptatum* (2, 3). In the tests reported herein, fern inoculated and cooled immediately after harvest did not decay while inoculated fern held at warm temperature developed severe decay (Table 3). In Rotterdam, we have observed considerable postharvest decay in fern harvested and shipped during late spring and summer while fern shipped during the winter months had little decay. These observations suggest that *C. heptaseptatum* may be more prevalent in the nurseries in Florida in the summer. Also, during the summer cut ferns are exposed to higher postharvest temperatures than in winter.

These data indicate that postharvest control of decay should be initiated in the nursery. The arrival of a decay-free product is assured if fern is harvested free of *Cylindrocladium heptaseptatum,* dipped in a fungicide and immediately cooled.

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COMMERCIAL FOLIAGE PLANT GROWERS' CLINIC—TRENDS REPORTED FOR A FIVE-YEAR PERIOD[1]

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Abstract. **The commercial foliage plant growers' clinic was established in 1976 by central Florida extension personnel to assist growers and to reduce demand on the Agricultural Research Center-Apopka (ARC-A) personnel. The number of grower visits to the clinic has steadily declined from a high of 1605 in 1976 to a low of 963 in 1980, indicating that growers have obtained a better understanding of their overall production problems. As grower visits have declined, so have the number of soil samples submitted for determination of pH and total soluble salts. Of the 3000 plus foliage plant problems diagnosed over this five-year period, the majority were cultural in nature and indicated an upward trend of this type of problem. This was accompanied by a concurrent decline in number of organism related problems. In addition, the complexity of grower problems has also increased, resulting in a larger number of problems which have not been diagnosed.**

The commercial foliage plant growers' clinic has been in operation since January, 1976. The purpose of this clinic has been to assist growers with their production problems and to reduce demand on faculty and staff at ARC-Apopka. The clinic, operated every Wednesday afternoon from 1 p.m. to 4 p.m. at ARC-Apopka, is staffed by Commercial Horticultural Extension Agents from the central Florida area with assistance by the research personnel from the center.