

Occurrence, Impact, and Fungicidal Control of Girdling Stem Cankers Caused by *Cylindrocladium scoparium* on Eucalyptus Seedlings in a South Florida Nursery

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ABSTRACT

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Cylindrocladium scoparium caused extensive losses of eucalyptus seedlings in a south Florida tree nursery by inducing girdling cankers on the lower stems of *Eucalyptus grandis* and *E. robusta*. Infections apparently started in the leaves and progressed through the petioles to the stems. Disease was enhanced by ambient nursery conditions, including overhead irrigation, high temperatures and humidity, and reduced aeration resulting from close seedling spacing. Seedlings with incipient stem infections recovered after being removed from the nursery environment and outplanted in the field. Seedlings with advanced stem lesions, however, generally failed to recover, although some initially resprouted from below the cankers after outplanting. Fungicide trials and operational experience indicate that infections can be controlled with regular applications of benomyl, chlorothalonil, and possibly, copper hydroxide.

Reports of pathogenicity of *Cylindrocladium* spp. on eucalyptus (*Eucalyptus* spp.) are numerous (1-4,6-15). The files of Florida's Division of Plant Industry contain reports of *C. scoparium* Morgan, *C. pteridis* Wolf, and *C. floridanum* Sob. & Seymour on at least seven *Eucalyptus* spp. In Florida, reports of *Cylindrocladium* spp. on eucalypt foliage predominate, but occurrence of *C. scoparium* has been confirmed on roots and stems as well.

Eucalyptus spp. have been grown in commercial nurseries in Florida for some years for use as ornamentals and experimental forest crops for wood fiber, energy wood, and/or solid wood products. In 1978, *C. scoparium* was repeatedly detected on the foliage of seedlings of several *Eucalyptus* spp. in a nursery of containerized forest seedlings in south central Florida. In October of the same year and again in 1979, this fungus caused girdling stem cankers that

resulted in serious damage to crops of *E. grandis* Hill ex Maid. and *E. robusta* Sm. This paper describes symptoms, distribution, impact, and fungicidal control of *C. scoparium* infections within this nursery. A preliminary report has been published (5).

MATERIALS AND METHODS

Nursery survey. In November 1978, a randomized survey was conducted to evaluate infections in seedling crops of *E. grandis* and *E. robusta* within the nursery. Fifty samples, each consisting of a Styrofoam block tray with 77 seedling cavities, were selected throughout the nursery using a random-number table. Eight additional sample trays were nonrandomly selected at loci of severe disease occurrence. Seedlings within each tray were individually assessed and the percentage of seedlings with advanced, apparently lethal, dark brown, black, and/or constricted stem cankers was recorded. More than 3,300 seedling stems

were evaluated.

Postoutplant survival. At the time of disease outbreak, questions arose as to 1) the ability of infected seedlings to survive after outplanting and/or 2) the ability of *C. scoparium* to kill seedlings removed from the nursery environment. Therefore, seedlings of *E. grandis* from the diseased crop were separated into three disease severity classes: 1 = healthy, no evidence of stem infection by *C. scoparium*; 2 = incipient, stems discolored (brown) but not black or constricted; and 3 = advanced, black and/or constricted stem cankers. Seedlings from each class were outplanted on a typical eucalyptus plantation site in plots containing five rows of six seedlings each. Each treatment was replicated three times in a Latin square design. Seedling survival was evaluated after 3 wk and again after 6 mo.

Fungicide trials. Natural inoculation. Fungicide trials were conducted in 1979. Plots of *E. grandis*, consisting of two Styrofoam trays each, were selected systematically in the nursery, and eight treatments (Table 1), replicated four times in a randomized complete-block design, were distributed therein. Fungicide sprays were applied at intervals of 7-14 days for 5 wk, beginning when seedlings reached a height of 10-15 cm. At the end of this period, seedlings were examined for *Cylindrocladium* infections. Seedlings from only the three most severely diseased plots within each treatment were individually assessed. One replicate with little or no disease was set aside from each treatment for artificial inoculation.

Artificial inoculation. Seedlings in the discarded replicate from each of the eight treatments were immediately resprayed

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Table 1. Fungicide treatments tested for control of *Cylindrocladium scoparium* on containerized eucalyptus seedlings in a south Florida nursery

Fungicide	Concentration (g/L)		Application*
	Label recommendation	Actual applied	
Bitertanol	0.6-1.2	0.96	FS ^b , 7-day intervals
Triadimefon	0.6+	0.60	FS, 14-day intervals
Benomyl	0.6-1.2	0.84	FS, 14-day intervals
Benomyl	0.6-1.2	0.84	DR, 0.95 L/plot, 14-day intervals
Chlorothalonil	1.2-1.8	1.92	FS, 7-day intervals
Copper hydroxide	1.8-3.6	1.92	FS, 7-day intervals
Mancozeb	1.8-3.6	3.60	FS, 7-day intervals
Metiram	1.8-3.6	2.16	FS, 7-day intervals

*All sprays (except benomyl DR) applied to runoff with a hand-held, pump-up sprayer. No adjuvants were employed.

^bFS = foliar spray, DR = drench.

with their respective fungicides. The next day, these seedlings were artificially inoculated with *C. scoparium*. Inoculum was prepared by comminuting two 10-day-old potato-dextrose agar (PDA) slant cultures of the pathogen in 150 ml of water. Seventy-five milliliters of inoculum suspension was atomized onto the seedlings within each of the two Styrofoam trays that constituted a treatment plot. Trays were then grouped randomly and surrounded by a border of trays with uninoculated seedlings to simulate typical nursery conditions. Inoculated seedlings were individually assessed for infection 12 days later.

Treatment effects for both naturally and artificially inoculated seedlings were determined by comparing the percentages of seedlings that had disease-free stems.

RESULTS

Nursery survey. Infected seedlings displayed leaf spots, foliar wilting and necrosis, stem lesions and discoloration, and girdling stem cankers. Advanced stem cankers were dark brown or black, typically constricted, and often centered at or near leaf nodes (Fig. 1) 3–10 cm above the soil line. Infected seedlings were frequently bent or broken at the loci of girdling cankers (Fig. 2B). Isolations from symptomatic tissues consistently yielded *C. scoparium*. Occasionally, the pathogen produced white tufts of conidiophores and conidia in profusion

on infected stems (Fig. 3).

Based on the random survey, the mean incidence of advanced stem cankers was 7.2%. Cankers were distributed throughout the seedling crop. Incidence within individual sample trays varied between 0 and 60%. Incidence in most trays was <10%.

Postoutplant survival. Many infected seedlings broke off at canker loci, either during planting or soon thereafter, especially if cankers were advanced at the time of outplanting. After 3 wk in the field, several such seedlings were sprouting from the root collar and/or the stem below the point of breakage (Table 2). *C. scoparium* was readily isolated from roots of class 3 seedlings that failed to sprout. After 6 mo, seedling establishment, mortality, and sprouting had stabilized, and only class 3 seedlings appeared to represent a significant risk in terms of field losses after outplanting. Seedlings in class 2 survived and/or

recovered to the point of equality with healthy class 1 seedlings (Table 2).

Fungicide trials. Fungicides were grouped according to relative effectiveness. In one group (Fig. 4A), apparent fungicidal protection, based on evaluation of three naturally inoculated replicate plots per treatment, did not hold up under the challenge of uniform, artificial inoculation. In the second group (Fig. 4B), apparent fungicidal protection held up very well under artificial inoculation. Chlorothalonil (Daconil 2787) and benomyl (Benlate 50WP) appeared to be most effective.

DISCUSSION

C. scoparium on eucalyptus is primarily a nursery problem (1,3,4,6,9,10), especially where seedlings are subjected to warm temperatures, high humidity, and close spacing (3,7,10). The containerized seedling system and overhead irrigation employed by the nursery considered in this report, together with south Florida's warm and humid climate, appear very conducive to disease development. Losses in this nursery in 1978 were estimated at \$2,000, and in 1979, about 200,000 seedlings valued at \$16,000 were destroyed by *C. scoparium*. This pathogen clearly represents a significant threat to nursery production of eucalyptus in Florida.

The symptoms of *Cylindrocladium* infections described in this paper are similar to those reported in South American literature as damping-off, neck rot, strangulation, or etiolation of eucalyptus seedlings (1,3,4,6,9,10). However, damping-off caused by *C. scoparium* was not observed in the south



Fig. 1. Cankers caused by *Cylindrocladium scoparium* on stems of eucalyptus seedlings. (A) Incipient cankers apparently initiated at leaf nodes. (B) Advanced stem canker showing stem constriction at nodes (arrows).

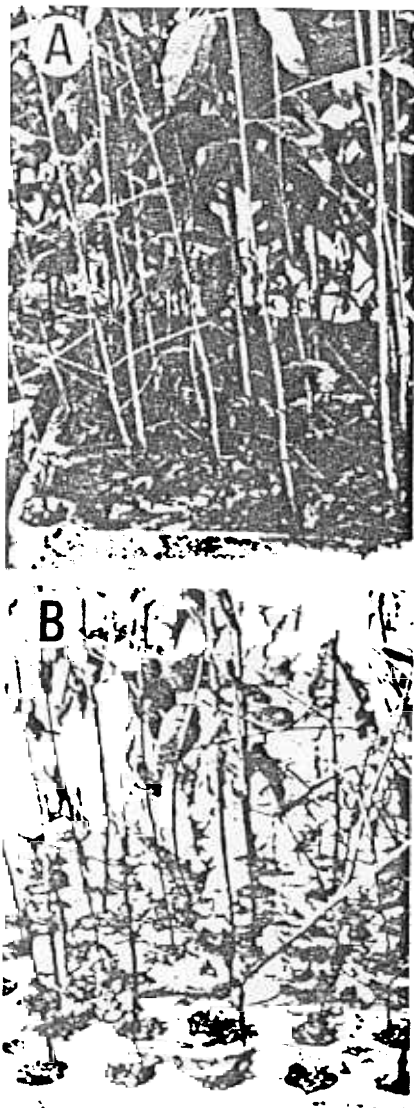


Fig. 2. (A) Healthy and (B) severely cankered stems of *Eucalyptus grandis*.

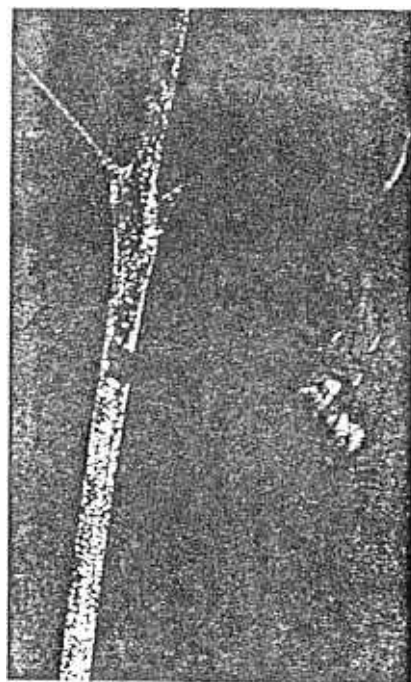


Fig. 3. Profuse white tufts of conidiophores and conidia of *Cylindrocladium scoparium* on an infected stem of *Eucalyptus grandis*.

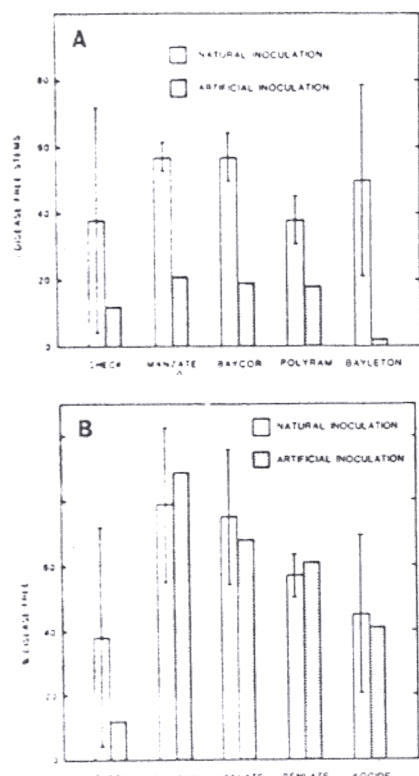


Fig. 4. Results of fungicide trials for control of girdling stem cankers caused by *Cylindrocladium scoparium* on seedlings of *Eucalyptus grandis*. (A) Fungicides that appeared effective under natural conditions but did not hold up under challenge of artificial inoculation. (B) Fungicides for which apparent protection under natural conditions held up well under artificial inoculation. Vertical lines in clear bars depict standard deviations for the means of three replicates per treatment evaluated under natural inoculation only.

Florida nursery. In contrast, the common occurrence of foliar infections and the high frequency of stem lesions at leaf nodes (Fig. 1) indicate that infections often progress from leaves into stems. In some cases, stem lesions appeared to have begun at points where infected leaves had wilted and wrapped around lower stems.

Seedlings with advanced infections generally failed to recover after outplanting. Although 50% of the seedlings with advanced infections sprouted from the lower stem or root collar within a few weeks of outplanting, all of these seedlings eventually died. In contrast, most seedlings with incipient infections at outplanting that appeared dead or were sprouting after 3 wk were fully recovered after 6 mo in the field (Table 2). Arruda (4) reported similar recoveries for germplasm transplanted to containers. The ready isolation of *C. scoparium* from root fragments of dead seedlings indicates that root infections may have

Table 2. Status of *Eucalyptus grandis* seedlings 3 wk and 6 mo after outplanting with and without stem infections of *Cylindrocladium scoparium*

Initial disease class	No. of stems ^a			
	3 Wk			6 Mo
	Alive ^b	Sprouting ^c	Dead	Alive ^b
Healthy	30.0	0.0	0.0	29.3
Incipient	27.7	1.7	0.7	29.3
Advanced	9.0	15.3	4.3	8.0

been partly responsible for seedling mortality. Further work is needed to determine whether root colonization preceded or followed seedling mortality and whether root infections arose independently or progressively from stem infections.

Fungicidal control of *C. scoparium* on seedling eucalyptus has been reported by others (7,12). Bertus (7) obtained varying degrees of control of foliar and stem blights using benomyl, carbendazim, thiabendazole, and thiophanate methyl. Reis and Chaves (12) reported control of the fungus as a damping-off agent with fentinacetate, ferbam, and zineb. Copper fungicides were reported by Reis and Chaves (12) to be phytotoxic to eucalyptus seedlings. In this study, benomyl and chlorothalonil provided the most effective control, although copper hydroxide (Kocide 101) showed promise as well. No evidence of phytotoxicity resulting from copper hydroxide applications was observed.

Since the extensive losses sustained in 1979 by the nursery described in this report, an operational fungicide spray program using benomyl and chlorothalonil has been employed. These materials are applied as foliar sprays on alternating weeks, beginning when seedlings are 10–15 cm high and continuing until seedlings are shipped to the field 2–3 mo later. Under this regime, losses to *C. scoparium* have not occurred.

Some success in controlling *Cylindrocladium* infections on eucalyptus through soil sterilization and/or fumigation has been reported (9,12). Although this approach may be useful in certain situations, fungicidal protection of seedling crops also appears necessary to prevent foliar infection. In the south Florida nursery, *C. scoparium* could be isolated readily from residual root fragments left in Styrofoam trays from previous seedling crops. Therefore, fumigation of Styrofoam trays with methyl bromide and use of pathogen-free commercial potting soil were employed as the backbone of a *Cylindrocladium*

control effort in 1979. This strategy alone failed to provide effective control.

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