Resistance in Twenty-two Cultivars of *Spathiphyllum* to *Cylindrocladium* Root Rot

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SUMMARY. Twenty-two *spathiphyllum* cultivars were evaluated for resistance to *Cylindrocladium* root rot (CRR). Four isolates of the fungus *Cylindrocladium spathiphylli* Shoult., El-Gholl & Alf. were selected from two different locations each in Florida and Hawaii. Spores of isolates were applied as a soil drench in replicated experiments using a randomized complete block design. The most severe symptoms were those produced by *C. spathiphylli* isolates from Hawaii. None of the *spathiphyllum* cultivars tested were highly resistant to CRR although resistance among the cultivars was observed. The cultivars Chris and Textura were the most promising cultivars, having fairly uniform resistance to the four isolates of *C. spathiphylli*. The cultivars Cupido, Daniel, Frederik, Jetty, and Vanessa were moderately resistant when combined data from all tests were analyzed. Results from this research permit the selection of more resistant breeding lines and also creates a baseline against which resistance of newly developed cultivars can be compared.

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The potted ornamental tropical foliage industry has a wholesale value of over \$514 million (Henley, 1996). Of the plants sold in the United States, *spathiphyllum* consistently outsells other popular foliage plants (Sheehan, 1994). The most damaging disease during *spathiphyllum* production is root rot caused by *Cylindrocladium spathiphylli*, first reported on *spathiphyllum* in the early 1980s (Schouties and El-Gholl, 1980, 1983). Losses in production caused by *Cylindrocladium* root rot (CRR) are most severe during warm summer months and uncommon during cooler periods of the year.

The first visible symptoms on infected *spathiphyllum* plants are chlorotic lower leaves and a wilted appearance, but these symptoms are secondary to the extensive root damage caused by this pathogen. Reddish-brown lesions, found on newly infected roots, expand rapidly causing total root collapse. Profuse numbers of spores are produced within infected root masses, providing inoculum that can be splashed onto leaves causing dime-sized circular brown necrotic lesions surrounded by yellow halos. In cool fall weather, fungal growth slows and the fungus over winters in infected roots. Plants that harbor the fungus will not show symptoms until warm weather conditions return. Therefore, when new tissue-cultured *spathiphyllum* plants are purchased, they should never be placed with established plants that may be infected with CRR.

Infected plants should be identified and removed from the production facility and remaining plants should be drenched with an appropriate fungicide. The most effective registered fungicides contain one of the following three compounds: triflumizole, thiophanate methyl, or copper sulfate (Norman, 1996).

However, since chemical control of CRR is expensive and not always effective (Norman, 1996), development of resistant cultivars through breeding would be the most desirable solution to manage this disease. In a previous report, CRR resistance was shown in two *spathiphyllum* species but not in commercial cultivars (Henny and Chase, 1986). Unfortunately, the resistant species have little ornamental potential and do not hybridize with

commercial cultivars. As a step toward the development of resistant cultivars, 22 popular commercial *spathiphyllum* cultivars were evaluated in this study.

Materials and methods

Twenty-two *spathiphyllum* cultivars were selected for this study (Table 1). Pathogen-free tissue-cultured *spathiphyllum* plants were obtained from Agri Starts, Inc. (Apopka, Fla.), Milestone Agriculture, Inc. (Apopka, Fla.), Oglesby Plant Lab. International, Inc. (Altha, Fla.) and Phoenix Foliage, Inc. (Winter Garden, Fla.) in 72-plug cell packs and were potted into 4-inch pots (10-cm), 177 inch³ (450 cm³) containing Vergo Container Mix A (Verlite Co., Tampa, Fla.) amended with Sierra plus minors 17N-6P-12K (Grace/Sierra, Milpitas, Calif.) at 0.05 oz/pot (1.5 g/pot). Plants were allowed to grow for 3 months before they were inoculated. To maximize genetic variability of the pathogen, four isolates (two from Florida and two from Hawaii) were selected from different locations in each state. Hawaii isolates were provided by J.Y. Uchida, University of Hawaii. Isolates were tested in a preliminary test to confirm pathogenicity. Experiments were conducted in a randomized complete block design with ten replications, with each replication consisting of a single plant. An eleventh block containing noninoculated control plants of each cultivar was isolated at one end of the bench to limit possible cross contamination from inoculated plants. Each isolate was inoculated onto the 22 cultivars during the warm July through September period. All experiments were conducted two times (1760 inoculated plants).

To generate sufficient spore counts for inoculation, isolates were incubated for 2 to 3 weeks on Difco Potato Dextrose Agar (PDA) at 77 ± 1 °F (25 ± 1 °C) under cool white fluorescent lights on a 12 h day/night cycle (9.4 mmol·m⁻²·s⁻¹). Fungal spores were harvested from PDA plates by flooding the plates with sterile distilled water (SDW) and scraping with rubber spatulas. Before inoculations, spore concentrations were adjusted in SDW with the aid of a hemacytometer to 1 × 10⁴ conidia/mL. Five milliliters of the spore suspension was added to each pot as a soil drench and 5 mL of SDW was added to noninoculated plant controls. *Spathiphyllum* plants were kept

Table 1. Resistance of 22 cultivars of *spathiphyllum* to isolates of *Cylindrocladium spathiphylli*.

Cultivar	Disease rating ^z				
	Florida isolates		Hawaii isolates		Combined
	95-246	96-258	97-227	97-228	
Alphia	3.0 d-g ^y	4.4 b-d	5.0 d	5.0 c	4.3 d-g
Babyface	4.6 h	4.5 b-d	5.0 d	5.0 c	4.7 g
Ceres	2.6 b-f	4.4 b-d	5.0 d	4.9 c	4.2 d-g
Chris	1.2 ab	3.7 b-d	4.4 b	4.5 c	3.5 b
Cody's Color	3.2 d-h	4.8 d	4.9 cd	5.0 c	4.5 d-g
Cupido	2.7 c-f	3.7 b-d	4.7 b-d	4.8 bc	4.0 b-f
Daniel	1.9 b-d	3.6 bc	4.9 cd	5.0 c	3.9 b-d
Frederik	2.2 b-e	4.3 b-d	5.0 d	4.9 c	4.1 bc-g
Jetty	1.8 b-d	3.9 b-d	5.0 d	4.9 c	3.9 b-e
Mascha	3.3 d-h	4.0 b-d	5.0 d	4.8 bc	4.3 d-g
Patrice	3.7 e-h	4.8 d	5.0 d	5.0 c	4.6 fg
Petite	3.9 f-h	4.9 d	5.0 d	5.0 c	4.7 fg
Piccolina	3.2 d-h	4.2 b-d	5.0 d	5.0 c	4.3 d-g
S18	2.7 c-f	4.1 b-d	5.0 d	5.0 c	4.2 c-g
Showpiece	4.3 gh	4.9 d	5.0 d	5.0 c	4.8 g
Sierra	3.1 d-g	4.4 b-d	5.0 d	4.9 c	4.4 d-g
Sonya	2.9 d-g	4.7 cd	5.0 d	4.8 bc	4.4 d-g
Taylor's Green	3.7 e-h	4.7 cd	5.0 d	5.0 c	4.6 e-g
Textura	1.4 a-c	3.3 b	4.6 bc	4.8 bc	3.5 bc
Ty's Pride	3.7 e-h	4.6 cd	5.0 d	5.0 c	4.6 e-g
Vanessa	2.7 b-f	4.0 b-d	5.0 d	4.9 c	4.2 b-g
Vicki Lynn	3.8 f-h	4.9 d	5.0 d	5.0 c	4.7 fg
Control (SDW)	0 a	0 a	0 a	0 a	0 a

^zPercent of roots exhibiting symptoms was visually estimated and percentages were ranked using a pretransformed rating scale (Little and Hills, 1978) as follows: 0 = no symptoms; 1 = 1 to 10%; 2 = 11 to 35%; 3 = 36% to 65%; 4 = >66% to 90%; 5 = 91% to 100%.

^yNumbers in same column followed by same letter are not significantly different using Tukey's LSD procedures at ($P \leq 0.5$).

in a fiberglass house maintained between 60 to 90 °F (16 to 32 °C) with a maximum light intensity of 266 mmol·m⁻²·s⁻¹. Percentage of roots exhibiting fungal disease symptoms was visually estimated 4 weeks after inoculation and values were ranked using a pretransformed rating scale (Little and Hills, 1978) as follows: 0 = no symptoms; 1 = 1% to 10%; 2 = 11% to 35%; 3 = 36% to 65%; 4 = 66% to 90%; 5 = 91% to 100%. Results from the four experiments were combined and data were compared using Tukey's LSD procedures. Reisolations from representative symptomatic plants were made to verify the presence of *C. spathiphylli* in each experiment.

Results and discussion

None of the *spathiphyllum* cultivars tested were immune to CRR although some resistance among the cultivars was observed (Table 1). The cultivars Chris and Textura are the most promising cultivars, having fairly uniform resistance to the four isolates

of *C. spathiphylli*. Five other cultivars Cupido, Daniel, Frederik, Jetty, and Vanessa were moderately resistant when combined data from all tests were analyzed. The most severe symptoms were produced by both isolates from Hawaii. It is not known why these isolates were more virulent than those from Florida. These results demonstrate that variations in virulence of *C. spathiphylli* isolates must be considered when attempting to incorporate resistance into a breeding program.

There are ≈35 species of *spathiphyllum*, most of which are native to the American tropics (Bailey and Bailey, 1976). There is no published information on genealogy of domestic cultivars; however, the extensive phenotypic variation evident among the cultivars indicates that hybridization has occurred. Currently, cultivars are derived either by selection of sports or through seed production.

CRR resistance in two *Spathiphyllum* species was reported to be regulated by a single dominant gene (Henny

and Chase, 1986). The range of responses demonstrated in this study indicates interspecific variation for resistance to the pathogen. Genetic basis for the resistance will be further studied. Integration of this resistance into commercial cultivars would be the best line of defense against this pathogen since this could reduce or eliminate the use of fungicides. Cultivar screening is one step toward developing resistant cultivars of *spathiphyllum* for resistance to CRR.

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