Effects of Potting Medium pH and Air Temperature on Severity of Cylindrocladium Root and Petiole Rot of *Spathiphyllum* sp.

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ABSTRACT

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Incorporations of dolomitic lime affected both potting medium pH and development of Cylindrocladium root and petiole rot of *Spathiphyllum* spp. During the fall, winter, and spring, plants grown with little or no added dolomite had more severe disease levels than plants grown with high levels of dolomite in the potting medium. Addition of dolomite at rates of 2.4–9.6 kg/m^3 of a Canadian peat-pine bark potting medium (50:50) resulted in a pH range of pot leachates of about 4.0 (no dolomite added) to 7.0 (9.6 kg/m^3). Efficacy of benomyl was not affected by these levels of dolomite. Although the same pH range was established in summer tests, disease severity was not affected. In similar tests employing $MgSO_4$ and $CaSO_4$, increased amounts of these compounds did not affect pH of pot leachate or disease severity. Although disease severity was affected by air temperature, there was no significant interaction between air temperature and pH. An interaction between temperature and pH was found for in vitro growth of *Cylindrocladium spathiphylli*, with poorest growth at pH 4.0 and incubation temperature of 32 C.

A wide variety of foliage plants are produced in many areas of the world for use in interiorscapes and homes. In Florida, species and cultivars of *Spathiphyllum* account for 10% of the foliage plants sold. The most serious disease of *Spathiphyllum* spp. is caused by *Cylindrocladium spathiphylli* Schoulties, El-Gholl, & Alfieri. Chemical control of Cylindrocladium root and petiole rot has met with limited success because highly effective fungicides are not labeled for this use (5). Some of the cultural controls that have been investigated include effects of host fertilization, irrigation frequency, potting medium components, and temperature (6). This study presents information on the effect of dolomitic limestone on pot leachate pH and subsequent disease development.

MATERIALS AND METHODS

Commercial *Spathiphyllum* L. 'Mauna Loa' seedlings were used in all studies. The basic potting medium consisted of Canadian sphagnum peat and non-composted pine bark (50:50, v/v) that was steamed for 1.5 hr at 88 C. This medium was amended with 4.4 kg of Osmocote 19N:6P:12K (Sierra Chemical Co., Milpitas, CA) and 0.9 kg of Micromax (micronutrient source from Sierra) per cubic meter. Other chemicals were added as specified for each experiment. A single 15-cm seedling was planted in each of 10 10-cm pots containing potting medium (about 50 g dry wt/10-cm pot). Experiments 1 and 2 were performed in a greenhouse with a temperature range of 15–35 C (seasonal fluctuation) and 200–250 μmol s^{-1} m^{-2} of natural light. Plants were watered two or three times per week depending on the time of year. Leachate was collected by pouring 50–100 ml of deionized water through the potting medium of each pot (10). The pH of the resulting leachate was tested monthly starting 3 days after treatments were initiated and continuing until the end of each test with a model 750 Fisher Accumet Selective Ion Analyzer (Fisher Scientific, Lexington, MA). Ratings for pH were changed to the [H^+] before analysis.

Plants were inoculated 1–2 wk after planting with 3-wk-old cultures of *C. spathiphylli* grown on freshly prepared potato-dextrose agar (PDA) medium under 20 μmol s^{-1} m^{-2} of light (cool-white fluorescent tubes) at 24–26 C. Inoculum was prepared by rubbing culture plates that were flooded with sterilized deionized water (SDW) with a rubber policeman to free the conidia. The resulting suspension was adjusted to 1 × 10^4 conidia per milliliter and added to the potting medium at the rate of 10 ml/10-cm pot and watered in lightly. Controls were treated similarly with SDW alone. Disease severity was rated weekly starting about 3–4 wk after inoculation when symptoms of disease started to develop. Disease severity was rated as the percentage of leaves showing symptoms of wilting, chlorosis, and necrosis. These percentage data were changed by the arc sine transformation of the square root of the percentage before analysis.

Effects of dolomite incorporation rate on disease severity, pot leachate pH, and benomyl efficacy. This experiment was performed as a 5 × 2 × 2 factorial. The levels of dolomitic limestone ($MgCO_3$ and $CaCO_3$) (75% passing a 100-mesh screen) were 0, 2.4, 4.8, 7.2, and 9.6 kg/m^3 of potting medium. Benomyl was applied weekly at the rate of 2.3 g/L (50 ml/10-cm pot). Controls received water applied in the same manner. The third factor was inoculation with *C. spathiphylli* or treatment with water 3 days after planting and 1 wk before benomyl treatments. These experiments were performed for about 10 wk and were repeated four times between November 1984 and November 1985.

Effects of $MgSO_4$ and $CaSO_4$ incorporation rates on disease severity and pot leachate pH. This experiment was similar to the first, except benomyl was not applied. Rates of $MgSO_4$ and $CaSO_4$ were 0 and 0, 1.3 and 1.7, 2.6 and 3.4, 3.9 and 5.1, and 5.2 and 6.8 kg/m^3, respectively. Twenty pots were used for each potting medium, with half of each treatment inoculated with *C. spathiphylli* and the remainder treated with SDW alone 3 days after planting. This test was performed over a 10-wk period, twice between April and September 1985.

Effects of dolomite incorporation rate and temperature on disease severity. A factorial design experiment evaluated effects of dolomite incorporation rate and temperature on disease severity. Dolomite was added at either 0 or 9.6 kg/m^3 of potting medium. Constant-temperature treatments were 17, 22, 27, and 32 C. Plants were placed in growth chambers (Plant Growth Chamber E 30B, Percival Manufacturing Co., Boone, IA) for 1 wk before inoculation of plants. This experiment was performed twice with five plants per treatment in each test.

Effects of culture medium pH and temperature on in vitro growth of *C. spathiphylli*. Four culture medium pH values and four temperatures were employed in this factorial test. The basal medium consisted of Difco PDA amended with 10.88 g of KH_2PO_4/L (8). This medium was adjusted to a pH of 4.0,

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5.0, 6.0, or 7.0 using 1 N HCl or 1 N NaOH. Five plates of each pH were incubated in the dark at constant temperatures of 17, 22, 27, or 32 C. After 2 wk, the radial growth of each plate was measured. This experiment was performed twice.

RESULTS

Effects of dolomite incorporation rate on disease severity, pot leachate pH, and benomyl efficacy. In the two tests conducted between November and March, disease severity was significantly reduced as amount of dolomite increased, with an interaction between dolomite and inoculation (Table 1). Mean daily high temperatures ranged from 18 to 26 C during these two tests. Benomyl treatment was not affected by amount of dolomite added to the potting medium; the same level of disease control was achieved regardless of the dolomite level. This relationship was not reproduced for two tests conducted between August and November, when temperatures were higher (Table 1). The mean daily high temperature range for these tests was 26–35 C. The time between inoculation and 50% plant mortality was about twice as long for the two tests conducted during cooler periods as for the two tests conducted during the fall. This indicates a higher degree of disease pressure occurred during the fall, when temperatures were higher. Values for leachate pH ranged from about 4.0 to 7.0 in all four tests, with increasing dolomite resulting in higher pH (Table 2). Neither inoculation nor benomyl treatment affected pH in any test.

Table 1. Effects of dolomitic lime incorporation rate on benomyl efficacy and on severity of Cylindrocladium root and petiole rot of *Spathiphyllum* plants grown in a greenhouse

Dolomite rate (D) (kg/m^3)	Percent disease[a] Test 1	Test 2	Test 3	Test 4
0.0	28.5**[b]	20.0**	16.8 ns	15.1 ns
2.4	20.0	17.5	13.1	13.2
4.8	12.5	10.0	17.5	12.2
7.2	7.5	5.0	21.2	19.3
9.6	5.0	10.0	16.2	20.0
Benomyl (B)				
No	20.8**	20.6**	nt[c]	nt
Yes	10.0	8.5	nt	nt
Inoculation (I)				
Yes	49.3**	51.0**	59.5**	52.4**
No	0.2	0.0	0.0	0.1
Interactions				
D × B	ns	ns	na[d]	na
D × I	**	**	ns	ns
B × I	**	**	na	na
D × B × I	ns	ns	na	na

[a] Percent disease values were transformed before analysis using the arc sine of the square root of each number. Values given are the means for 10 pots.
[b] Significance of the *F* test within columns for each test denoted as ns = not significant and ** = $P = 0.01$.
[c] Not tested.
[d] Not applicable.

Table 2. Effects of dolomitic lime incorporation rate on pH of potting medium leachate of *Spathiphyllum* plants grown in a greenhouse

Dolomite rate (D) (kg/m^3)	Mean leachate pH[a] Test 1	Test 2	Test 3	Test 4
0.0	3.75**[b]	4.10**	5.50**	4.65**
2.4	4.95	4.45	6.25	5.15
4.8	6.25	5.15	6.50	5.60
7.2	6.70	5.70	6.50	5.90
9.6	7.00	5.90	6.70	6.00
Benomyl (B)				
No	4.40 ns	4.60 ns	nt[c]	nt
Yes	4.35	4.55	nt	nt
Inoculation (I)				
Yes	4.35 ns	4.60 ns	5.95 ns	5.05 ns
No	4.45	4.60	6.15	5.30
Interactions				
D × B	ns	ns	na[d]	na
D × I	ns	ns	*	*
B × I	ns	ns	na	na
D × B × I	ns	ns	na	na

[a] Leachate pH values were changed to the [H^+] before analysis. Values given are means for four pots.
[b] Significance of the *F* test within columns for each test denoted as ns = not significant, * = $P = 0.05$, and ** = $P = 0.01$.
[c] Not tested.
[d] Not applicable.

Effects of $MgSO_4$ and $CaSO_4$ incorporation rates on disease severity and pot leachate pH. Increasing amounts of dolomite increased leachate pH. Tests performed with the sulfates of Mg and Ca, adjusted to give the equivalent amount of Mg^{+2} and Ca^{+2} as corresponding dolomite treatments, had no effect on pH as their rate of addition was increased (Table 3). Similarly, disease severity was not affected by addition of these compounds.

Effects of dolomite incorporation rate and temperature on disease severity. Results of the two growth chamber studies were similar and were therefore combined for statistical analysis. Both temperature and dolomite affected severity of Cylindrocladium root and petiole rot (Table 4). Mean disease severity was 38.3 for plants in unamended potting medium (leachate pH 4.0) compared with 10.3 for plants in amended potting medium (leachate pH 6.5). In addition, disease severity was highest at 27 C, with little disease developing at 17 C and decreased development at 22 or 32 C (Table 4). There was no interaction between temperature and dolomite in either test.

Effects of culture medium pH and temperature on in vitro growth of *C. spathiphylli*. In vitro growth of *C. spathiphylli* was highest at 27 C, although significant growth occurred at 17 and 22 C and less growth occurred at 32 C (Table 5). Although pH significantly affected growth of the pathogen, the greatest radial growth at any given temperature differed. At 17 C, growth decreased as pH increased, whereas at 32 C, growth increased as pH increased.

DISCUSSION

Soil pH has been shown to affect severity of many root diseases. Root diseases of poinsettia caused by *Thielaviopsis basicola* (Berk. & Br.) Ferr. and *Pythium ultimum* Trow are more severe at a soil pH higher than 5.5 (2). Similar results have been published for *T. basicola* on *Ilex crenata* Thunb. (9). Root rot of rhododendron caused by *Phytophthora cinnamomi* Rands also is more severe at a pH range of 5.7–6.0 than at pH 3.4–3.7 (3). In contrast, applications of lime to a soil with an initial pH of 4.8 raised the pH to 6.5 and decreased the severity of Cephalosporium stripe of winter wheat (4). Our studies with Cylindrocladium root and petiole rot on

Table 3. Effects of $CaSO_4$ and $MgSO_4$ incorporation rates on potting medium leachate pH and Cylindrocladium root and petiole rot severity of *Spathiphyllum* plants grown in a greenhouse

$CaSO_4 + MgSO_4$ (kg/m^3 medium)	Percent disease[a]		Mean leachate pH[b]	
	Test 1	Test 2	Test 1	Test 2
0.0 + 0.0	15.0 ns	15.0 ns	3.40 ns	3.45 ns
1.3 + 1.7	5.0	15.0	3.60	3.35
2.6 + 3.4	12.5	15.0	3.60	3.35
3.9 + 5.1	15.0	15.0	3.55	3.20
5.2 + 6.8	12.5	20.0	3.70	3.20
Inoculation				
Yes	46.0**[c]	56.0**	3.60 ns	3.45**
No	0.2	0	3.55	3.15

[a] Percent disease values were transformed before analysis using the arc sine of the square root of each number. Values given are means for 10 pots.
[b] Leachate pH values were changed to $[H^+]$ before analysis. Values given are means for four pots.
[c] Significance of the *F* test within columns for each test denoted as ns = not significant and ** = *P* = 0.01. Interactions between factors were not significant.

Table 4. Effects of dolomite amendment and temperature on severity of Cylindrocladium root and petiole rot of *Spathiphyllum* plants grown in growth chambers

Temperature (T) (C)	Percent disease[a] (dolomite rate [kg/cm^3])		Mean (temperature)
	0	9.6	
17	5.0[a]	0.0	2.5**[b]
22	34.0	7.0	20.5
27	74.0	33.0	53.5
32	40.0	1.0	20.5
Mean (dolomite)	38.3**[b]	10.3	(T × D) ns

[a] Percent disease values were transformed before analysis using the arc sine of the square root of each number. Values given are means for 10 pots.
[b] Significance of the *F* test for each factor within columns denoted as ns = not significant or ** = *P* = 0.01.

Table 5. Effects of pH and temperature on in vitro radial growth of *Clyindrocladium spathiphylli*

Temperature (T) (C)	Mean growth (cm) at each culture medium pH				Mean (temperature)
	4.0	5.0	6.0	7.0	
17	40.7[a]	34.7	37.9	35.9	37.3**[b]
22	45.7	30.8	37.3	42.8	39.2
27	46.1	45.8	48.7	48.4	47.2
32	22.5	26.0	28.5	26.3	25.8
Mean (pH)	38.8**	34.3	38.1	38.4	(T × pH)**

[a] Mean diameter of 10 replicate plates on potato-dextrose agar medium after 2 wk of growth.
[b] Significance of the *F* test for each factor denoted as ** = *P* = 0.01.

Spathiphyllum showed that an increase in potting medium pH by addition of dolomitic lime decreased disease severity. It appears that the effect of soil pH on root diseases varies with both pathogen and host involved. Although low pH has been shown to decrease efficacy of benzimidazoles (1), benomyl provided the same degree of disease control at pH 3.8 as it did at pH 7.0 in this work.

Severity of Cylindrocladium root and petiole rot of *Spathiphyllum* increases as potting medium temperature increases up to 30 C but decreases at 32 C (6). Previous research on *Spathiphyllum* has shown that potting medium temperatures of 32 C significantly reduce growth of this plant as well (7). An interaction between potting medium temperature and pH was described in this paper. Although high pH decreased disease severity during the winter and spring, it did not affect disease severity during the summer, because disease pressure at those temperatures was highest. Disease development is so rapid during the summer that the effect of dolomite is negligible.

In vitro studies with *C. spathiphylli* showed that pH and temperature interact to affect growth of the pathogen; poorest growth occurs at the lowest pH and highest air temperature tested. It is possible that when optimum temperatures for disease development exist, the effect of potting medium pH is not significant because of the relatively higher disease pressure. During late fall, winter, and early spring, severity of Cylindrocladium root and petiole rot of *Spathiphyllum* can be minimized by maintaining a neutral potting medium pH.

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