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Pathogenicity of *Pythium aphanidermatum* and *Fusarium oxysporum* on Snapdragon

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***Fusarium oxysporum* (F) and *Pythium aphanidermatum* (P) were isolated from a diseased snapdragon (*Antirrhinum majus*) planting near Stuart, FL, in 2003. Plants exhibited stem rot and dieback. Snapdragons were inoculated with F, P, or F+P, or were treated with culture media of each fungal treatment. A negative control treated with water was included. In Trial 1 and Trial 2, both treatments with the presence of *Pythium* (P and P+F) reduced plant height, shoot and root weights, and numbers of flowers compared to the control. Although F slightly reduced plant growth relative to the negative control, plant growth was not different ($P < 0.05$) between F and potato dextrose broth (PDB) alone, the substrate for F. When volume of the PDB was reduced in Trial 2, F did not reduce plant growth. In Trial 3 and Trial 4, P and F from the diseased plants in Trial 1 and Trial 2 were re-isolated and inoculated on new plants, confirming the pathogenicity of P on snapdragon and fulfilling Koch's postulates for this pathogen. Young snapdragon seedlings were more susceptible to P than older plants. Young seedlings infected with P showed the stem rot and dieback symptoms as observed in the field where the disease outbreak had originally occurred. Plants inoculated with F did not show these symptoms, confirming that this isolate was not pathogenic.**

Snapdragon (*Antirrhinum majus* L.) is increasing in its importance in the cut flower market of the United States, with a wholesale value of $15 million in 2004 (US Department of Agriculture, 2005). Although a few growers have produced snapdragon in pots on raised benches (Sullivan and Pasian, 2001), traditionally snapdragon is grown in the field. When snapdragon is planted in the ground, it is subjected to many soilborne pests and diseases. A disease outbreak was found in a commercial snapdragon production area near Stuart, in Martin County, FL, in 2003 after a rainy season (McSorley et al., 2004). Water runoff from an unfumigated border area contaminated the snapdragon planting beds that were previously treated with methyl bromide. Diseased plants developed symptoms of stem rot and dieback. *Fusarium oxysporum* (F) and *Pythium aphanidermatum* (P) were frequently isolated from the diseased stem and root tissues.

Pathogens reported on snapdragon in Florida include *Fusarium* sp. that caused basal stem and root rot, *Pythium* sp. that caused root and crown rot, *P. spendens* that caused damping off, and *Rhizoctonia* sp. and *R. solani* that caused root and stem rot (Alfieri et al., 1994; Gulf Coast Research and Education Center, 2002). *Pythium ultimum* was found to cause severe root rot on snapdragon in California (Paulus et al., 1983), whereas *P. cylindrosporum*, *P. irregulare*, and *P. ultimum* were isolated from snapdragon in Pennsylvania (Moorman et al., 2002).

Disease complexes caused by *Fusarium* spp. and *Pythium* spp. have been reported in many crops such as bean (Pieczarka and Abawi, 1978), cotton (Lyda and Watkins, 2001), clover, alfalfa (Kucharek, 1997), rapeseed (Barbetti and Roy, 1982), peanut (Csinos et al., 1984), and strawberry (Pscheidt, 2005). It is possible that a similar disease complex could also be occurring in snapdragon.

The objective of this research was to test the pathogenicity of a *Fusarium* spp. isolate and a *Pythium* spp. isolate obtained from the field disease outbreak on snapdragon. A Koch's postulate (Agrios, 1988) approach was used to test the hypothesis that *Fusarium* spp. and *Pythium* spp. are pathogenic to snapdragon, and therefore may have caused the observed disease outbreak. The pathogens were re-isolated and inoculated on snapdragon plants (both young plants and older plants) to confirm the pathogenicity, and to examine the effect of plant age on susceptibility to the pathogens.

Materials and Methods

Isolation of fungi. Declining snapdragon seedlings collected from the production site were washed with running tap water for 15 min. Tissue from the rotted basal stem area of the seedlings was surface sterilized with 0.6% NaOCl (sodium hypochlorite) solution for 30 s, and plated on acidified potato dextrose agar (PDA) (Shurtleff and Averre, 1999). The pieces of plant stem tissue were approximately 1 mm × 0.5 mm. Plates were incubated in the dark for 2–3 d at room temperature (23 °C). Cultures of fungal isolates were subcultured using hyphal tips cut from the colonies under a dissecting microscope, and placed, one colony per plate, onto PDA for further use.

Isolates of *Fusarium* spp. were transferred to carnation leaf agar

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(CLA) (Nelson et al., 1983) to stimulate sporulation for identification purposes. *Fusarium* isolates were allowed to grow for 10 d at room temperature (23 °C) with exposure to natural light. Isolates were sent to the Fusarium Research Center (Pennsylvania State University, University Park) for species identification. *Pythium* spp. isolates were transferred to pond water and grass blade medium (Mitchell and Rayside, 1986). Plates were incubated at 23 °C for 48 h, and then *Pythium* species were identified based on the morphological characteristics of sporangia, antheridia, and oogonia of the genus using the key from Van der Plaats-Niterink (1981).

Inocula production. The *F. oxysporum* isolate was seeded in a 2-L flask containing potato dextrose broth (PDB). Three pieces of approximately 25-mm^2 mycelial disks taken from an actively growing colony on potato dextrose agar (PDA) were added to the flask. The culture was incubated for 14 d at ambient temperatures on the laboratory bench and was agitated twice a day to provide aeration for the fungus.

For the *P. aphanidermatum* inoculum, three pieces of the isolate from acidified PDA culture were transferred to 9-cm-diameter petri dishes containing a sterile solution of pond water and 10 pieces of grass blades of Kentucky bluegrass (*Poa pratensis*) per dish. These grass blades were 10–12 cm long and were previously boiled for 10 min in distilled water (Mitchell and Rayside, 1986). Grass blades were macerated in a blender, and the *Pythium* culture was incubated in a suspension of pond water and macerated grass blades (PWGB) for 48 h at approximately 25 °C. The P culture was then transferred to a refrigerator (10 °C) for 15–30 min to stimulate the exudation of zoospores.

Spores produced in the culture were estimated with the aid of a hemacytometer (Orbeco Analytical Systems, Inc., Farmingdale, NY). Small samples of *P. aphanidermatum* zoospore suspensions in test tubes were mixed in a vortex mixer for 30 s to induce encystment of zoospores for counting on a hemacytometer (Mitchell and Rayside, 1986). A mixture of macro- and microconidia of *F. oxysporum* were also counted on the hemacytometer.

Pathogenicity tests (Trial 1 and Trial 2). Koch's postulates were used to test the pathogenicity of a *Pythium* isolate (P) and a *Fusarium* isolate (F) in two greenhouse trials. In Trial 1, seedlings (2–3 cm tall) of snapdragon 'Potomac Pink' planted in pathogen-free, soilless medium were obtained from Sunshine State Carnations in Martin Co., FL. Each seedling was transplanted to a 10-cm-diameter plastic pot containing 680 g autoclaved sand : peat mix (4:1; v/v) on 18 Jan. 2005. One week after transplanting, root zones of plants were stabbed 3 times with a knife to create wounding on the roots. Plants were then inoculated with F (9.7×10^7 spores in 50 mL PDB), P (1×10^6 spores in 6.5 mL PWGB), or F+P (half of the amount of F and P), or were treated with the corresponding volume of culture media of each fungal inoculum (PDB, PWGB, or PDB+PWGB). A negative control without fungus and culture medium was included. The experiment was arranged in randomized complete-block design with five replications of the seven treatments on a raised bench, for a total of 35 pots. All pots were supported by plastic dishes to catch excess water from irrigation, and to produce moist conditions conducive for disease development. Plants were watered and fertilized as needed, and grown under shadecloth with 50% ambient light. Mean maximum and minimum temperatures in the greenhouse were 32 and 14 °C, respectively, over the course of the experiment.

Plant heights were recorded every 2 weeks. The experiment was terminated on 20 Apr. 2005, 3 months after inoculation. Shoot and root weights, numbers of flower buds or blooms, and root damage index on a scale of 0 to 5 (0 = no damage; 1 = 1–25%; 2 = 26–50%; 3 = 51–75%; 4 = 75–99% damage; 5 = 100% of root system damaged) were recorded for each plant.

The experiment was repeated as Trial 2 beginning on 5 Aug. 2005. The seven treatments were carried out in the same manner as in Trial 1 except for some slight differences. Inoculum density for F was 1.1×10^8 spores in 40 mL of PDB and for P was 3.3×10^6 spores in 40 mL of PWGB. Half of the amount of these inocula was used in the F+P treatment. Based on the heat units accumulated for both trials, Trial 2 was terminated 2 months after inoculation, on 3 Oct. 2005. Mean maximum and minimum temperatures in the greenhouse were 34 and 24 °C, respectively. Data collected were similar to Trial 1.

At termination of both trials, a subsample of each snapdragon root system was plated out on acidified PDA to re-isolate the fungi inoculated.

Reinoculation tests (Trial 3 and Trial 4). One isolate each of P and F isolated at the termination of both trials (four isolates total) were used to inoculate snapdragon plants to confirm the cause of the observed symptoms. The experiment was conducted twice; one test involved inoculation of 1.5-cm-tall seedlings (Trial 3), and the other test utilized snapdragon plants averaging 82 cm tall (Trial 4). Both trials were inoculated on 12 May 2006. An experimental protocol similar to Trial 1 and 2 was used, with 'Potomac Pink' snapdragons planted into sterile sand : peat mix. Treatments included: two isolates of P (P-I and P-II = isolates from Trial 1 and Trial 2, respectively), two isolates of F (F-I and F-II), PWGB, PDB, and a negative control. Inoculum densities for F-I and F-II were 5.5×10^7 spores and 1.6×10^7 spores/40 mL PDB, respectively. Inoculum densities for P-I and P-II were 1.5×10^6 and 1.7×10^6 spores/40 mL PWGB, respectively. Similar volumes of PDB, PWGB, and water were used for all the control treatments. Trial 3 was terminated on 16 July. However, due to the older age of plants used, Trial 4 was first harvested on 2 June by collecting top biomass clipped 20 cm above the soil-line. The plants were then allowed to form new shoots and grown until 20 July. Plant heights were recorded at weekly intervals. At the termination of each trial, data were collected as described for Trial 1. For Trials 3 and 4, average maximum temperature was 35 °C and average minimum temperature was 22 °C.

Statistical analysis. Plant heights, gain in plant heights (final height – initial height), top weights, root weights, root disease index, numbers of blooms, numbers of flower buds, and total numbers of flowers (flower buds and blooms) were subjected to one-way analysis of variance for each trial separately, using PROC GLM in SAS software (SAS Institute, 2000). Treatment means were separated using Waller–Duncan k-ratio (k = 100) t-test when significant differences ($P \leq 0.05$) were detected.

Results

Isolation of fungi. Nine isolates of *Fusarium* spp. were collected from rotten basal stem parts of the snapdragon seedlings from a field in Martin County. Species identified by the Fusarium Research Center included two isolates of *Fusarium oxysporum*, three isolates of *F. equiseti*, and four isolates of *F. semitectum*. Five isolates of *Pythium* spp. were collected from diseased tissues, and all were identified as *P. aphanidermatum*. One isolate of *P. aphanidermatum* and one isolate of *F. oxysporum* were selected for the pathogenicity tests.

Pathogenicity tests. Average initial plant heights in Trial 1

Table 1. Effects of *Pythium aphanidermatum* and *Fusarium oxysporum* on snapdragon (Trial 1).

Treatment[z]	Plant ht (cm)	Top wt (g)	Root wt (g)	Flowers (no.)	Root damage index[y]
F	105.8 b[x]	42.63 c	9.61 ab	18 b	0.2 c
P	43.6 c	5.08 d	1.14 c	2 c	5.0 a
F+P	36.4 c	5.20 d	1.32 c	1 c	4.0 b
PDB	104.2 b	49.51 bc	8.22 ab	22 b	0 c
PWGB	116.2 ab	58.26 ab	10.13 a	31 ab	0 c
PDB+PWGB	103.4 b	46.56 bc	7.46 b	22 b	0 c
C	124.6 a	68.45 a	9.62 ab	41 a	0 c

[z]F = *Fusarium oxysporum*; P = *Pythium aphanidermatum*; PDB = potato dextrose agar; PWGB = pond water and glass blades; C = water-treated control.

[y]Root damage rated on 0 to 5 scale, where 0 = no damage, 1 = 1–25%, 2 =26–50%, 3 = 50–75%, 4 = 75–99%, and 5 = 100% of root damaged.

[x]Means in a column followed by the same letter do not differ at $P \leq 0.05$ according to Waller–Duncan k-ratio *t*-test.

Table 2. Effects of *Pythium aphanidermatum* and *Fusarium oxysporum* on snapdragon (Trial 2).

Treatment[z]	Plant ht (cm)	Top wt (g)	Root wt (g)	Flowers (no.)	Root damage index[y]
F	56.9 ab[x]	16.22 ab	2.00 a	10 a	0.2 b
P	18.5 b	0.85 b	0.05 a	0 a	5.0 a
F+P	35.0 ab	6.74 ab	0.93 a	4 a	4.2 a
PDB	48.8 ab	16.19 ab	2.16 a	7 a	0.5 b
PWGB	62.7 a	20.50 a	2.54 a	19 a	1.5 b
PDB+PWGB	39.5 ab	18.45 ab	2.40 a	12 a	1.5 b
C	49.4 ab	19.67 a	2.45 a	18 a	0 b

[z]F = *Fusarium oxysporum*; P = *Pythium aphanidermatum*; PDB = potato dextrose agar; PWGB = pond water and glass blades; C = water-treated control.

[y]Root damage rated on 0 to 5 scale, where 0 = no damage, 1 = 1–25%, 2 =26–50%, 3 = 50–75%, 4 = 75–99%, and 5 = 100% of root damaged.

[x]Means in a column followed by the same letter do not differ at $P \leq 0.05$ according to Waller–Duncan k-ratio *t*-test.

and Trial 2 were 4.8 cm and 13.6 cm, respectively. In both Trial 1 and Trial 2, *Pythium* was pathogenic to snapdragon (Tables 1, 2). Plant height and shoot weight were consistently lower in P as compared to PWGB and the untreated control ($P < 0.05$) in both tests. *Pythium* also suppressed ($P < 0.05$) root weight and numbers of flowers in Trial 1 but not in Trial 2. In Trial 1, all P-treated plants survived, and only showed wilted symptoms without dieback. In Trial 1, *Pythium* colonies were recovered from the roots of four out of the five P-treated plants when plated on acidified PDA. In Trial 2, four out of five P-treated plants were dead, and *Pythium* colonized the roots of the only surviving P-treated plant.

Although plant height, shoot weight, and numbers of flowers of snapdragon were lower in F than in C, all plant growth and yield parameters were not different between F and PDB ($P > 0.05$, Tables 1, 2). In Trial 1, all plant growth and plant yield parameters were lower in PDB than C. However, PDB did not reduce plant growth and yield as compared to the control in Trial 2. Only three of five, and one of five root systems were colonized by *F. oxysporum* in Trial 1 and Trial 2, respectively.

The combination of P+F did not cause more reduction in snapdragon growth and yield compared to P alone (Tables 1 and 2). In fact, in Trial 1, P alone resulted in a higher ($P < 0.01$) root damage index than P+F (Table 1). In Trial 1, all P+F plants survived, but in Trial 2, four out of five P+F-treated plants were dead. In Trial 1, although both *F. oxysporum* and *P. aphanidermatum* colonies were found in all root systems, all of the acidified PDA plates were dominated by *Pythium* colonies. In Trial 2, only three of the root systems could be plated on PDA. *Pythium* colonized all three of these root systems, whereas *F. oxysporum* only colonized two of these root systems.

Reinoculation tests. In Trial 3, when P isolated from Trial 1 and Trial 2 were inoculated on younger snapdragon seedlings (1.5 cm tall), most of the seedlings showed similar symptoms as observed in the field where the disease outbreak originally occurred. The seedlings showed symptoms of stem rot and dieback. The few seedlings that survived P infection showed a higher ($P < 0.05$) root damage index compared to all other treatments (Table 3), and *P. aphanidermatum* was consistently isolated when the roots were plated on acidified PDA. Plant height, shoot weight, and numbers of flowers were significantly lower ($P < 0.05$) in P-I and P-II treated plants than all other treatments (Table 3). However, root weight was not different ($P > 0.05$) between

Table 3. Effects of *Pythium aphanidermatum* and *Fusarium oxysporum* isolated from Trials 1 and 2 and inoculated on young snapdragon seedlings (Trial 3). Data were collected 2 months after inoculation.

Treatment[z]	Plant ht (cm)	Top wt (g)	Root wt (g)	Flowers (no.)	Root damage index[y]
P-I	0.63 c[x]	0.00 c	0.00 b	0 c	5 a
P-II	12.33 c	1.81 c	0.21 b	0 c	4 a
F-I	83.28 a	35.95 a	2.31 ab	26 a	1 b
F-II	57.98 b	10.70 b	1.42 b	12 b	0 bc
PWGB	83.93 a	32.98 a	2.95 ab	27 a	0 c
PDB	92.20 a	36.42 a	5.96 a	15 b	0 c
C	92.08 a	30.35 a	3.45 ab	26 a	0 c

[z]F = *Fusarium oxysporum*; P = *Pythium aphanidermatum*; PDB = potato dextrose agar; PWGB = pond water and glass blades medium; C = water-treated control; I and II indicate isolates obtained from Trial 1 and Trial 2, respectively.

[y]Root damage rated on 0 to 5 scale, where 0 = no damage, 1 = 1–25%, 2 =26–50%, 3 = 50–75%, 4 = 75–99%, and 5 = 100% of root damaged.

[x]Means in a column followed by the same letter do not differ at $P \leq 0.05$ according to Waller–Duncan k-ratio *t*-test.

Pythium-treated plants and PWGB and C at termination of the trial. Only one isolate of *Fusarium* (F-II) reduced plant height and shoot weight compared to PDB and C, but it did not reduce numbers of flowers as compared to the PDB control (Table 3). Colonies of *F. oxysporum* were only re-isolated from five out of the eight F-treated plants when their roots were plated on acidified PDA.

Reduction in plant growth by *Pythium* was less severe in Trial 4 when the plants were inoculated at an older stage (Table 4). Only one P-II inoculated plant died in Trial 4. *Pythium* did not consistently suppress snapdragon growth at the first harvest in Trial 4, but by the second harvest on 13 July, *Pythium* consistently suppressed all growth and yield parameters measured and resulted in a higher root damage index than the controls (Table 4). *Pythium* was isolated from roots of all P- treated plants. Neither of the isolates of *Fusarium* suppressed plant growth or yield in Trial 4 (Table 4), and only one root system out of eight F-treated plants was colonized by *F. oxysporum*. However, PDB on several occasions reduced plant growth (shoot and root weights) as compared to the water-treated control (Table 4). No *Fusarium* or

Table 4. Effects of *Pythium aphanidermatum* and *Fusarium oxysporum* isolated from Trials 1 and 2 and inoculated on old snapdragon plants (Trial 4). Data were collected at 2 weeks (2 June 2006) and 2 months (13 July 2006) after inoculation.

Treatment[z]	Plant ht (cm)	Dry top wt (g)	Plant ht (cm)	Top wt (g)	Root wt (g)	Flowers (no.)	Spikes (no.)	Root damage index[y]
	------- 2 June 2006 -------		---------- 13 July 2006 ----------					
P-I	87.50 b[x]	2.61 c	34.30 bc	5.50 c	1.26 c	0.00 c	0.00 c	3.75 a
P-II	92.95 ab	2.57 c	17.10 c	3.13 c	0.78 c	0.00 c	0.00 c	4.00 a
F-I	95.73 ab	3.60 abc	74.93 a	36.24 a	5.46 ab	31.25 ab	3.00 a	0.00 b
F-II	98.58 a	3.85 ab	69.35 a	39.29 a	6.60 a	33.75 a	3.25 a	0.00 b
PWGB	92.40 ab	3.36 abc	70.78 a	39.18 a	6.00 ab	31.50 a	2.75 ab	0.00 b
PDB	95.48 ab	3.12 bc	52.43 ab	24.27 b	4.12 b	20.75 b	2.25 b	1.25 b
C	102.05 a	4.35 a	75.15 a	39.94 a	7.17 a	28.25 ab	1.50 ab	0.00 b

[z]F = *Fusarium oxysporum*; P = *Pythium aphanidermatum*; PDB = potato dextrose agar; PWGB = pond water and glass blades; C = water-treated control; I and II indicate isolates obtained from Trials 1 and 2, respectively.
[y]Root damage rated on 0 to 5 scale, where 0 = no damage; 1 = 1–25%; 2 = 26–50%; 3 = 50–75%; 4 = 75–99%; and 5 = 100% of root damaged.
[x]Means in a column followed by the same letter do not differ at $P \leq 0.05$ according to Waller–Duncan k-ratio *t*-test.

Pythium colonies were found on the roots of PDB-treated plants when plated on acidified PDA.

Discussion

All four trials clearly demonstrated that the *P. aphanidermatum* isolate was pathogenic to snapdragon, whereas the *F. oxysporum* isolate was not. Combination of *P. aphanidermatum* and *F. oxysporum* did not cause a more severe disease than *P. aphanidermatum* alone. While we could demonstrate that *P. aphanidermatum* reduced snapdragon growth and yield in the pathogenicity tests (Trial 1 and Trial 2), we could not consistently repeat the same disease symptoms occurring in the disease outbreak in the field near Stuart. *Pythium* inoculation did not cause dieback in Trial 1, but caused 80% mortality in Trial 2. Plants were inoculated at average seedling heights of 4.8 cm and 13.6 cm in Trial 1 and Trial 2, respectively. The relatively older ages of snapdragon during the inoculation in Trial 1 and Trial 2 could have affected the susceptibility of snapdragon to *Pythium*. Therefore, when P was inoculated on younger seedlings (1.5 cm tall) in Trial 3, we could repeat the stem rot and dieback symptoms observed in the field, and found 100% mortality within 1 week after inoculation. When older plants were inoculated at an average seedling height of 82.0 cm in Trial 4, almost all snapdragons survived P infection despite reduction in plant growth and yield. Effects of plant age on disease development of other species of *Pythium* have been demonstrated on rice (*Oryza sativa* L.) (Chun and Schneider, 1998). Susceptibility of rice seedlings to three species of *Pythium* was sharply reduced from 2 to 6 d after planting, and seedlings were completely resistant at 8 d after planting.

However, the effect of plant age did not explain the 80% mortality rate on P-infected plants in Trial 2, which were inoculated at a slightly older stage (13.6 cm tall) than those in Trial 1. Two explanations are that plants in Trial 2 received a slightly higher inoculum density (3.3×10^6 spores) compared to the other trials ($<2.0 \times 10^6$ spores), and that Trial 2 was also conducted during warmer months than the other trials.

In Trial 1, F reduced plant heights and flower numbers more than the untreated control, but plants treated with F did not differ from those treated with PDB alone. This suggested that PDB might have supported the growth of other mild pathogen strains in the root system after the inoculation, or PDB could be phytotoxic to the snapdragon. When a lower amount of PDB (40 mL instead of 50 mL) was used in Trial 2, plant growth and yield were not suppressed by PDB compared to the control. Only occasionally, PDB (40 mL) reduced plant growth or flower yields in Trial 3 and Trial 4. Root assay on acidified PDA indicated that the *F. oxysporum* isolate did not colonize snapdragon as efficiently as the *P. aphanidermatum* isolate.

In conclusion, based on the data presented, we rejected the hypothesis that *P. aphanidermatum* and *F. oxysporum* are the causal agents for the disease outbreak that occurred near Stuart. Of course, other untested species or isolates may have been responsible for all or part of the disease outbreak, but this can never be known with certainty. In our pathogenicity tests, only the *P. aphanidermatum* isolate was shown to be pathogenic to snapdragon. If *P. aphanidermatum* was responsible, then during the disease outbreak, *P. aphanidermatum* resulted in 67% cut flower yield lost in non-fumigated plots, and 34% in plots receiving soil fumigants such as methyl bromide and metam sodium or solarization treatments (McSorley et al., 2004). This is the first report of damage of *P. aphanidermatum* on snapdragon in Florida. Results of the current study suggest that crop loss may be minimized if older seedlings were transplanted into an infested field. This disease outbreak also reminded us of the importance of managing soilborne pathogens even when the field had been fumigated prior to planting. Proper sanitation should be practiced to avoid water run-off from contaminated soil into fumigated areas. In addition, wide ranges of fungicides have been demonstrated to be effective for managing *Pythium* disease (Chase, 1999). A guideline for managing diseases on ornamental plants is summarized by Bledsoe et al. (2004). In addition, we previously examined the susceptibility of four species of cut flowers, lisianthus [*Eustoma grandiflorum* (Raf.) Shinn.], snapdragon, white dill (*Ammi majus* L.), and larkspur [*Consolida ajacis* (L.) Schur.] to the *Pythium* in soil from this site near Stuart. White dill was tolerant to the fungal pathogens in this soil (Malek et al., 2005). Therefore, the grower may also consider rotating snapdragon to white dill in a *Pythium*-infested site.

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