

Stem Rot, Cutting Rot, and Leaf Spot of *Dieffenbachia maculata* 'Perfection' Incited by *Fusarium solani*

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ABSTRACT

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Fusarium solani was isolated from *Dieffenbachia maculata* 'Perfection' plants, collected from several commercial nurseries in Florida, with symptoms of stem rot, cutting rot, and leaf spot. Symptoms were reproduced when pathogen-free plants were inoculated with conidial suspensions of *F. solani*. Inoculation of tissue-cultured dieffenbachias with conidial suspensions resulted in death or varying degrees of stunting, depending on inoculum concentration. Inoculations of other members of the family Araceae did not produce disease, although *Brassaia actinophylla* (schefflera) was susceptible.

Dieffenbachias are widely grown foliage plants estimated to be worth about \$6 million annually in Florida alone. Several diseases that occur throughout the industry cause severe losses to growers. Perhaps the most serious pathogen of dieffenbachias is *Erwinia chrysanthemi* Burk. et al (1,2), which has been present in their culture for at least 20 yr. No known chemicals effectively control this systemic bacterium, and disease results in losses up to 100%.

Over the past 3 yr, diseased *Dieffenbachia maculata* (Lodd.) G. Don 'Perfection' have been collected from several commercial nurseries in Florida. Symptoms included stem and cutting rots, leaf spot, and seed rot. Stem rot often started at the end of a cutting made on the mother plant. A dry rot about 2-5 mm deep appeared initially. Stem centers were sunken and soft, often resulting in their loss from the mother plant. Occasionally, lesions began at the soil line of uncut stems, most frequently associated with an emergence point of an aerial root. These lesions were purplish red and up to 3 cm long. The stem often collapsed after the pathogen progressed into the stem center (Fig. 1). Bright red perithecia and masses of ochre-colored conidia were

noted within rotting tissue in both types of stem infection. In some cases, the end of the tip cutting was rotted (Fig. 2). Leaf spots were found on cuttings rooted under conditions of high moisture. Spots enlarged rapidly to form papery, necrotic areas up to 3 cm in diameter (Fig. 3). Infection also occurred along petioles and had the purplish red coloration of stem infections. Finally, a seed rot that resulted in fruit decay was found on many dieffenbachias used in a breeding program.

We conducted this research to determine the causal agent of dieffenbachia stem and cutting rots and leaf spot and to investigate the host range of the causal organism.

MATERIALS AND METHODS

The causal organism was isolated from tissue from diseased dieffenbachias collected from several commercial nurseries in Florida. Leaf, petiole, and stem tissues from both cuttings and rooted plants were surface-disinfested in 0.52% sodium hypochlorite for 2-3 min and rinsed in sterile, deionized water. Tissue was plated on potato-dextrose agar (PDA) (infusion from 250 g of boiled potatoes, 20 g of agar, and 20 g of dextrose per liter), PDA amended with 100 µg/ml streptomycin sulfate (PDAS), selective pythiaceus media (PVP, PVPH) (5,6), and selective *Fusarium* agar (SFA) (4). Plates were incubated at 24-27 C for 7 days with 8 hr per day of fluorescent light (2.2 klux). The frequency and identity of fungi were then determined.

Concurrently, the presence of bacteria in the tissue was determined. Tissue from each area was washed in tap water; finely chopped in a small amount of sterile, deionized water; and allowed to stand for 30 min for bacteria to diffuse from the tissue. The resulting suspension was diluted with sterile, deionized water and streaked onto nutrient agar medium (BBL Microbiology Systems, Cockeysville, MD 21030) and crystal

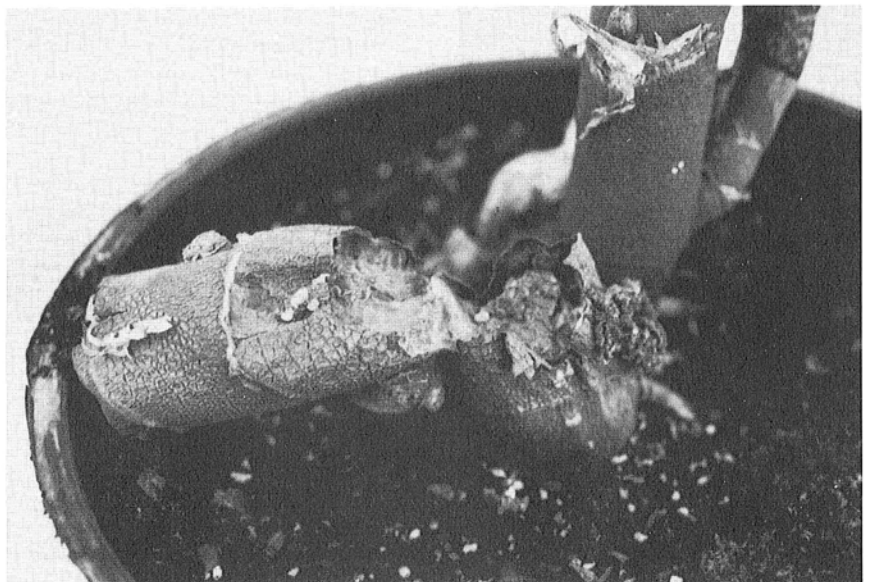


Fig. 1. *Fusarium* stem rot of an unidentified dieffenbachia, incited by *Fusarium solani*.

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violet-pectate agar (3) and incubated for 48 hr at 24–26 C. Colonies suspected of being *Erwinia* spp. were isolated and tested by standard bacteriological methods (3).

The pathogenicity of the suspect pathogen to dieffenbachia was tested on *D. maculata* 'Perfection' plants grown from cuttings removed from pathogen-free plants produced through tissue culture. Cuttings were rooted in steam-sterilized potting medium (Canadian peat, cypress shavings, and pine bark; 2:1:1 by volume), which was amended



Fig. 2. Naturally occurring cutting end rot of *Dieffenbachia maculata* 'Perfection' incited by *Fusarium solani*.



Fig. 3. Leaf spot of *Dieffenbachia maculata* 'Perfection' from an artificial inoculation with *Fusarium solani*.

with 6 kg of Osmocote (14-14-14, slow release fertilizer; Sierra Chemical Co., Milpitas, CA), 1 kg of Perk (micronutrient source; Estech, Inc., Chicago, IL 60604), and 4 kg of dolomite per cubic meter of medium. Throughout this study, plants were watered twice a week by hand and grown on raised benches in a glasshouse with about 10.8 klux of natural light.

Inoculum was prepared from a single-conidium isolate of the suspect pathogen on PDA. The isolate was transferred to PDA plates and incubated at 24–26 C for 7–10 days with 8 hr per day of fluorescent light (2.2 klux). A conidial suspension was used as inoculum in some experiments, a mycelial disk (5 mm in diameter) in others. To prepare conidial suspensions, we added sterile, deionized water to a culture plate and gently rubbed the surface of the colony with a sterile rubber spatula. The resulting conidial suspension was counted with a hemacytometer and adjusted to 1×10^6 conidia per milliliter by the addition of sterile, deionized water. The suspect pathogen was reisolated on either PDAS or SFA by the procedure described above.

Ten rooted cuttings with at least two side shoots each were inoculated with conidia or sterile, deionized water. Before inoculation, the central shoot of each plant was removed with a sterile razor blade and discarded. The conidial suspension was sprayed on the cut ends at the rate of 1 ml per plant. Plants were placed in polyethylene bags for 48 hr and then arranged randomly on a bench. Symptoms were recorded several times during the next 6 wk. This test was performed at least three times with each isolate of the suspect pathogen.

In the second series of tests, an inoculum disk was placed into a 1-cm wound made longitudinally in Perfection dieffenbachia stems. Ten plants each were inoculated with a disk of sterile PDA and 10 others with a disk cut from the advancing edge of a colony with a no. 2 cork borer. The wound was sealed with a strip of parafilm for 1 wk. Plants were placed randomly on a bench for observation. This experiment was performed three times with each suspect pathogen.

To determine the effect of the pathogen on leaves, three leaves on each of five plants were punctured five times with a sterile dissecting needle. The wounds were sprayed to the point of runoff with either the conidial suspension or sterile, deionized water. Plants were randomly placed on a bench receiving mist for 30 sec every 30 min from 0800 through 1900 hr. Plants were rated three times at 2-wk intervals for number and size of lesions. Any lesions that formed on unwounded tissue also were recorded and measured. The test was performed twice with Perfection plants and twice with *D. maculata* 'Rudolph Roehrs' grown in the same manner as Perfection plants.

We investigated the effect of the suspect pathogen on rooting of cuttings by removing 25 cuttings each from pathogen-free Perfection plants with sterile razor blades and dipping the ends into a conidial suspension or sterile, deionized water. The cuttings were then planted in sterile 2:1:1 mix and enclosed in polyethylene bags for the duration of the test. At 30 days, the cuttings were removed from pots and the number of roots, length of the longest root, and presence of disease were recorded. This experiment was performed three times.

Tissue-cultured Perfection plants (15 per treatment) with good root development were each dipped into sterile, deionized water or conidial suspensions of 1×10^2 , 1×10^4 , or 1×10^6 conidia per milliliter. They were planted in steam-sterilized 2:1:1 medium, watered lightly, and enclosed in polyethylene bags until they had acclimated to soil. About 3 wk later, they were removed from the bags and placed randomly on a glasshouse bench where they were watered as needed and received about 10.8 klux of natural light. Plant height was recorded once a month. Isolations were made from dead plants by the method described earlier. Visual symptoms such as chlorosis and presence of perithecia also were recorded monthly, and after 6 mo, isolations were made from all plants. This experiment was performed twice.

We tested two groups of plants to determine the host range of the suspect pathogen. The first group of plants were related to dieffenbachia in the family Araceae, and the second group included a wide range of foliage plants. Cuttings from the following araceous plants were rooted under mist in the 2:1:1 potting medium: *Aglaonema commutatum* Schott 'Silver Queen'; *D. maculata* 'Perfection'; *Epipremnum aureum* (Linden & Andre) Bunt (pothos); *Philodendron hastatum* C. Koch & H. Sello, not Hort. Sc. (Red Emerald); *P. scandens oxycardium* C. Koch & H. Sello (heartleaf philodendron); and *Syngonium podophyllum* Schott (nephthytis). *Spathiphyllum* sp. Schott 'Clevelandii' also was inoculated. Five plants per species were each inoculated with a mycelial disk of inoculum as described earlier; five other plants were inoculated with sterile PDA as controls. Development of symptoms was noted over a 6-wk period, and the suspect pathogen was reisolated in the standard manner. This test was performed twice.

The second group of plants was chosen on the basis of reports of isolation of the suspect pathogen from them. The following plants were either rooted from cuttings or obtained from growers as seedlings: *Aphelandra squarrosa* Nees (zebra plant); *Brassaia actinophylla* Endl. (schefflera); *Chamaedorea elegans* Mart. (parlor palm); *D. maculata* 'Perfection'; *Dracaena marginata* Lam.; *Ficus*

benjamina L. (weeping fig); and *Hedera helix* L. (English ivy). Five plants of each species were used for each of three treatments. In the first treatment, 1 ml of a 1×10^6 conidia per milliliter suspension was applied to the soil around the stems of the plants. The second treatment involved stem inoculation with mycelial disks as described earlier. The final treatment combined the first two treatments but used sterile, deionized water and sterile PDA disks. Plants were randomly arranged on a glasshouse bench and observed for 6 wk. At the end of the test, plants were examined for symptoms of root rot, and tissue from roots and stems was plated as previously described. This test was performed once with all of the plants and two other times with schefflera and dieffenbachia alone.

RESULTS

Fusarium solani (Sacc.) Mart. emend. Snyd. & Hans. was the only organism consistently isolated from leaves, petioles, stems, and seeds of diseased dieffenbachias. At no time were any organisms previously reported to cause leaf spot or stem rot of dieffenbachia isolated from any plants. Symptoms of the infected dieffenbachias were initially confused with *Erwinia* blight, which also causes a soft stem rot and leaf spot. However, the symptomatology indicated that *Erwinia* sp. was not responsible for all of the symptoms, and attempts to isolate the bacterium were not successful. Isolation of *F. solani* was equally successful on PDAS and SFA, and both media were employed throughout these studies.

Only plants inoculated with a mycelial disk of *F. solani* (98%) or conidial suspension of the pathogen (50%) developed the typical sunken soft lesions. Plants inoculated with other fungal isolates or with the sterile medium did not develop any symptoms of disease. *F. solani* was reisolated only from those plants inoculated with it. Results were the same for each of the pathogenicity trials. Only *F. solani* isolates caused stem rot of dieffenbachias.

Only *F. solani* incited lesions on leaves of inoculated plants. Lesions developed in only 5% of inoculation sites but also developed occasionally on unwounded leaves inoculated inadvertently. Over a 2-mo period, lesions reached about 1 cm in diameter and had concentric light and dark brown rings in the necrotic area. In some cases, a chlorotic halo surrounded the necrotic areas. No fruiting bodies were found in any of these lesions such as those found in lesions of other common leaf spots of dieffenbachia; isolations from lesions yielded *F. solani* only. Wounded areas on plants inoculated with sterile, deionized water did not develop into necrotic areas, and no organisms were isolated from them. Results were the same for both cultivars tested.

Inoculation of cuttings taken from pathogen-free dieffenbachias did not result in severe cutting rot such as that seen in naturally infected plants. Symptoms of cutting rot developed in only three plants in one of the three tests. Because plants were maintained in plastic bags throughout the test, the foliage was kept moist and petiole lesions were noted as well as cutting rot. The pathogen had no statistically significant effect ($P = 0.05$) on the number or length of roots formed on these cuttings compared with control plants. *F. solani* was reisolated from the base of the cuttings as well as the petiole lesions but not from any other area.

Inoculations of small, tissue-cultured plants with conidial suspensions of the pathogen resulted in stunting and plant death (Table 1). Plants inoculated with 1×10^2 conidia per milliliter did not die during the test, and their heights were not statistically different from those of uninoculated plants. Plants inoculated with 1×10^4 conidia per milliliter were again statistically the same size as control plants, although about 17% of them died over the 5 mo of the test. The greatest losses occurred in plants inoculated with 1×10^6 conidia per milliliter (Fig. 4). After 1 mo, 17% of the plants in that treatment had died and by the end of the test, 83% were dead. Although low inoculum levels did not significantly reduce plant size, a general trend toward reduction of plant growth was noted. The pathogen was reisolated from dead plants in each case. In about 10% of the bases of dead plants, perithecia of *Nectria haematococca* Berk. et Br. were identified. *F. solani* was reisolated from inoculated plants only. Results in the second and third tests were similar.

In the host range tests on members of the Araceae family, only dieffenbachia was susceptible to *F. solani*, and the pathogen was reisolated from this plant only. Although isolation reports had indicated that the nonaraceous plants tested were hosts of *F. solani*, only

schefflera was susceptible to this pathogen in our tests. Schefflera inoculated with *F. solani* developed symptoms of both root rot and stem rot resembling those seen in dieffenbachias. Some schefflera died within 1 mo of inoculation with the pathogen. Neither roots nor stems of any other plant showed any signs of disease. Subsequent tests employing only schefflera and dieffenbachia gave similar results.

DISCUSSION

Fusarium stem rot, cutting rot, and leaf spot of dieffenbachia encompass a wide range of symptoms, and the possibility of known pathogens causing similar symptoms was recognized. However, at no time in these tests were any of the known pathogens of this plant isolated. Pathogenicity tests proved that *F. solani* incited symptoms of stem and cutting rots and leaf spot as well as death of tissue-cultured plants. Although seeds were not inoculated with *F. solani*, the organism is readily isolated from diseased seed and is a probable cause of their decay.

Symptoms resemble those caused by *Erwinia* spp., so diagnosis based on symptomatology is not reliable. When determination of the causal organism by

Table 1. Effect of inoculation with conidial suspensions of *Fusarium solani* on growth and mortality of tissue-cultured *Dieffenbachia maculata* 'Perfection'

Treatment	Mortality ^x (%)	Mean plant height (cm) ^{x,y,z}
Water	0	16.33 a
10^2 conidia/ml	0	14.04 a
10^4 conidia/ml	17	14.58 a
10^6 conidia/ml	83	6.33 b

^x Calculated for 12 plants at the final rating.
^y The last height obtained for each plant was used to determine the mean if the plant died before the final rating.

^z Numbers in a column followed by the same letter were not significantly different, according to Duncan's multiple range test ($P = 0.05$).

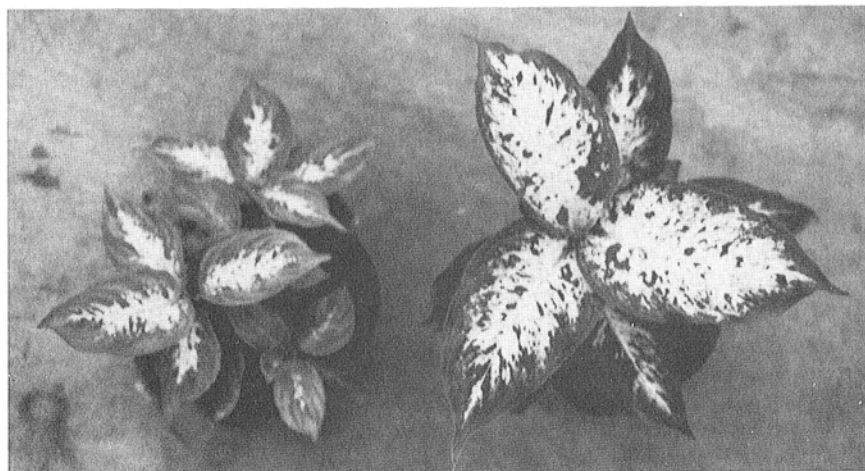


Fig. 4. Stunting and poor foliage contrast caused by *Fusarium solani* on tissue-cultured *Dieffenbachia maculata* 'Perfection' (left), compared with a healthy plant (right).

culturing is not possible, the following information may aid in diagnosis. Dieffenbachia plants infected with *Erwinia* spp. frequently have a distinctive rotten odor, which is absent in dieffenbachias infected with *Fusarium* sp. Lesions caused by *F. solani* have a reddish purple border not seen in lesions caused by *Erwinia* spp. Finally, the presence of perithecia of the perfect state of the fungus is the best noncultural indication of the causal organism. The possibility that both *F. solani* and *Erwinia* spp. may be contributing to the disease should not be overlooked.

Because effective treatment of the disease is possible only through accurate diagnosis, isolation of the causal agent(s) is recommended highly. *Erwinia* blight of dieffenbachia is not effectively controlled with pesticide sprays, but severity of *Fusarium* stem rot and leaf spot can be reduced with several fungicides currently on the market (A. R. Chase, *unpublished*). Observations of *Fusarium* stem rot indicate that the causal organism is not eradicated easily once established in a greenhouse; avoidance of disease through use and maintenance of pathogen-free

stock is the best control.

The variation of symptom expression may be partly the result of the nature of dieffenbachia propagation. Many of the symptoms do not occur unless plants are being rooted or cuttings are being removed and the water level is high in both the potting medium and the air. In most situations, only stem rot around aerial roots and a few leaf spots develop without mechanical injury. Other foliage plants, such as schefflera, which are propagated by seed, may be susceptible; however, disease problems are not known to occur, because they are propagated under different conditions than dieffenbachia.

No reports in the literature demonstrate the role of *F. solani* in a disease of a foliage plant, although records of the Division of Plant Industry of the Florida Department of Agriculture and Consumer Services show that it has been isolated from many other plants. An isolate of *F. solani* from *Rhododendron indicum* (L.) Sweet was also pathogenic to dieffenbachia, inciting the same symptoms of disease (A. R. Chase, *unpublished*). Although the host range of *F. solani* on

foliage plants includes only two genera at this time, the potential of this pathogen to cause other foliage plant diseases should be recognized.

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