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Resistance Levels of Pot Anthurium Cultivars to *Xanthomonas campestris* pv. *dieffenbachiae*

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Abstract. **One cut-flower and 14 pot anthurium cultivars were screened for resistance to anthurium blight by spraying four isolates of *Xanthomonas campestris* pv. *dieffenbachiae* (McCulloch and Pirone) Dye onto leaf surfaces in replicated experiments. Varying degrees of resistance were observed among the 15 cultivars tested. The pot cultivars Julia and Gemini were the most resistant, while the cut-flower cultivar Hearts Desire was the most susceptible. Each cultivar displayed different degrees of resistance to individual isolates of the pathogen. The results of this research permit the selection of clones with greater resistance for use in breeding and also create a baseline for comparing resistance of newly developed cultivars.**

Worldwide losses in anthurium production are caused by anthurium blight, incited by *Xanthomonas campestris* pv. *dieffenbachiae*. Extensive losses to anthurium blight have been reported in the Philippines (Natural, 1990), French West Indies (Prior et al., 1986), Jamaica (Young, 1990), Tahiti (Mu, 1990), and Venezuela (Guevara and Debrot, 1987). Within the United States, this bacterial pathogen is commonly found in commercial production facilities in Florida (Norman, 1997), California (Cooksey, 1985) and Hawaii (Hayward, 1972; Lipp et al., 1992). Most blight infections of anthurium commence through entrance at hydathodes on the leaf margins or wounds. Guttation droplets form at hydathode openings at night when planting media is warm and saturated with water, and humidity is high. Amino acids found in guttation fluid provide nutrients for invading bacteria (Sakai, 1990). First visible symptoms on plants are chlorotic water-soaked spots on leaf margins, which rapidly develop into necrotic v-shaped lesions. Most plants exhibit symptoms within 2 to 3 weeks after infection. The infections quickly become systemic and, once infected, plants may produce leaves with a bronzed appearance. Eventually, infected plants wilt and die. However, some infected plants can remain asymptomatic for months while the bacteria multiply and spread throughout the plant; such plants can exude guttation fluid containing bacteria which can infect adjacent plants.

While production of tissue-cultured plants has greatly reduced the incidence of the blight in pot anthurium cultivars, many pot anthurium producers also cultivate other Araceae taxa that are a potential source of infection. They include such genera as *Aglaonema, Dieffenbachia, Epipremnum, Philodendron, Spathiphyllum*, and *Syngonium*. Asymptomatic cuttings of these genera are shipped into the United States from countries such as Costa Rica, Guatemala, and Honduras. Subsequently, imported plants may be grown adjacent to or above anthurium plants. The bacteria are then easily spread from infected plants by dripping guttation fluid or irrigation water, contaminated propagation tools, or by workers handling plants. No chemical control method has been found for anthurium blight.

Most cut-flower anthurium cultivars are selections of *A. andraeanum* Lind. Lipp et al. (1992) found that three such cultivars expressed different degrees of resistance to several isolates of *X. campestris* pv. *dieffenbachiae*. Anthurium pot cultivars have been derived from crosses of *A. andraeanum* with dwarf clumping species such as *A. amnicola* Dressler and *A. antioquiense* Engler. Little information exists on the resistance of pot anthurium cultivars to the bacterium. This study was conducted to determine the reactions of several pot anthurium cultivars to four isolates of *X. campestris* pv. *dieffenbachiae*.

Materials and Methods

Fourteen pot anthurium cultivars were selected for this study along with 'Hearts Desire', a cut-flower (control) cultivar of *A. andraeanum*, (Table 1). Pathogen-free tissue-cultured plants were obtained from Agri Starts (Apopka, Fla.), Oglesby Plant Laboratories (Altha, Fla.), and Twyford Plant Laboratories (Santa Paula, Calif.) in plant cell plugs and were potted into 15-cm pots (2119 cm^3) containing Fafard Mix No. 2-P (Fafard Co., Apopka, Fla.) amended with Sierra Plus Minors 17N–6P–12K (Grace/Sierra, Milpitas, Calif.) at 2.5 g/pot. The plants were kept in a fiberglass house maintained between 16 to 32 °C, with light at ≈260 $\mu mol \cdot m^{-2} \cdot s^{-1}$, and were hand-watered to prevent spread of disease should it occur. Plants were allowed to grow for 10 to 12 months before inoculation.

X. c. pv. *dieffenbachiae* isolates from anthurium were initially screened for virulence, and four isolates were selected. To insure a heterogenic pathogen population, two isolates were selected from each of the two biotypes, only one of which can hydrolyze starch. To further assess the pathogens' genetic variability, two isolates were selected from Florida, one from California, and another from Hawaii (Table 1). Experiments were conducted in a randomized complete-block design, with six blocks, each of which contained one plant per cultivar. A seventh block containing noninoculated control plants of all cultivars was isolated from the other blocks to limit possible cross-contamination from inoculated plants (total of 105 plants per test). Each test of the 15 cultivars was conducted twice, with each of the four bacterial isolates during hot weather from July through September for a total of eight separate tests (840 plants total).

For production of bacterial inoculum, cultures of *X. c.* pv. *dieffenbachiae* were grown for 48 h at 28 ± 1 °C on Difco Nutrient Agar (NA; Difco Laboratories, Detroit) amended with 5% (w/v) sucrose. Bacteria were harvested, suspended in saline (NaCl, 8.5 $g \cdot L^{-1}$) and adjusted spectrophotometrically at A_{600} to 1×10^8 colony-forming units/mL. Leaves and stems were sprayed with the bacterial suspension and enclosed in a clear polyethylene bag for 24 h. Inoculated plants were kept in a fiberglass house, as described above. In each experiment, noninoculated plants (sprayed with saline) of the cultivars were used as controls. Percentage of foliage exhibiting bacterial disease symptoms was visually estimated after 4 weeks, 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%. Reisolations from representative symptomatic plants of each cultivar were made to verify presence of the causal disease agent in each experiment. Results from the replicate experiments with each bacterial isolate were pooled and data were compared using analysis of variance (ANOVA) and Tukey's least significant difference (LSD) procedure. Additional LSD comparisons were made within biotypes and for the entire experiment.

Results and Discussion

None of the 15 anthurium cultivars was immune, but some of the pot cultivars exhibited relatively high resistance to infection. The broadest horizontal resistance to the four isolates of the bacterium tested was observed with the cultivar Julia (Table 1). Of the 56 'Julia' plants inoculated in eight experiments, 27% (15/56) showed no symptoms of infection and the remainder had only slight marginal chlorosis and water-soaking symptoms on leaves. *X. c.* pv. *dieffenbachiae* could only

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Table 1. Resistance[z] of 14 hybrid pot cultivars and one cut-flower cultivar of anthurium to four isolates of *Xanthomonas campestris* pv. *dieffenbachiae*.

	Xanthomonas isolates[y]						
	Starch +			Starch –			
Cultivar	X476 Hawaii	X641 Florida	X476 + X641[x]	X758 Florida	X1272 California	X758 + X1272[x]	All isolates[w]
Crystal Hope	1.3 bc[v]	2.3 e–g	1.8 c–f	2.9 g	3.7 f	3.3 g	2.6 fg
Gemini	1.3 bc	1.0 bc	1.1 bc	0.8 bc	1.1 b	1.0 bc	1.1 bc
Improved Lady Anne	2.1 c–e	1.0 bc	1.5 b–d	0.9 b–d	1.3 bc	1.1 bc	1.3 cd
Julia	1.0 bc	0.7 ab	0.8 b	0.3 ab	1.1 b	0.7 b	0.8 b
Lady Anne	3.1 f	2.6 fg	2.8 hi	1.8 d–f	2.8 e	2.3 ef	2.6 fg
Lady Beth	1.9 b–d	1.7 c–f	1.8 c–f	1.3 cd	1.7 b–d	1.5 cd	1.7 de
Lady Ruth	2.8 d–f	2.4 e–g	2.6 f–i	1.2 cd	1.8 b–d	1.5 cd	2.1 ef
Mary Jean	2.5 d–f	2.1 d–g	2.3 e–i	1.6 c–e	1.9 cd	1.8 de	2.0 e
Northstar	1.8 b–d	1.6 b–e	1.7 c–e	0.9 b–d	1.3 bc	1.1 b–d	1.4 cd
Pink Frost	2.6 d–f	2.4 e–g	2.5 f–i	2.6 fg	2.9 ef	2.7 fg	2.6 g
Pura Vida Lavender	2.4 d–f	1.2 b–d	1.8 c–f	0.9 b–d	1.2 bc	1.1 bc	1.4 cd
Pura Vida Red	2.3 d–f	1.8 c–f	2.1 d–g	0.9 b–d	1.6 b–d	1.3 b–d	1.7 de
Red Hot	2.1 c–f	1.6 b–f	1.9 d–f	1.2 cd	1.7 b–d	1.5 cd	1.7 de
Show Biz	2.3 d–f	1.9 c–f	2.1 d–h	1.1 b–d	1.7 b–d	1.4 cd	1.8 de
Hearts Desire (cut-flower)	2.9 ef	2.9 g	2.9 i	2.3 e–g	2.4 de	2.4 ef	2.7 g
Control (noninoculated)	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a

[z]Percentage of foliage 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%.
[y]Two isolates capable of hydrolyzing starch (starch +); two not capable (starch –).
[x]Means for both isolates.
[w]Means for all four isolates.
[v]Mean separation within columns by ANOVA and Tukey's LSD, $P \leq 0.5$.

occasionally be reisolated from the leaf margins of the asymptomatic plants. This cultivar apparently is capable of resisting infection even with high disease pressure. 'Julia' is an interspecific hybrid of *A. amnicola* x *A. antioquiense* that was backcrossed to *A. antioquiense. Anthurium antioquiense* is native to the Pacific coast of Colombia, is a relatively small plant, producing narrow leaves and small white flowers, and has never gained acceptance as a pot anthurium cultivar. Tolerance of this species to bacterial blight has been reported in Hawaii (Kamemoto and Kuehnle, 1996). The cultivar 'Gemini' had disease ratings that were slightly more severe than 'Julia', although not significantly different. 'Gemini' is a sport of the cultivar 'Pink Aristocrat' (not tested in this study), which is a selection from crosses made between *A. amnicola, A. antioquiense,* and *A. andraeanum.* 'North Star' is also a sport of 'Pink Aristocrat' and was not significantly different from 'Gemini' in resistance.

Genetically, most cut-flower anthurium cultivars grown in Hawaii are seedling selections from within *A. andraeanum.* 'Hearts Desire', a selection of *A. andraeanum,* was one of the most susceptible tested in this study. Little genetic resistance appears to exist in cultivars of *A. andraeanum,* as heavy losses to anthurium blight have occurred in Hawaii for the past 15 years.

The remaining cultivars tested in this study, except for 'Crystal Hope', were derived from crosses of *A. andraeanum* with either *A. antioquiense* and/or *A. amnicola.* Each of these cultivars showed varying degrees of resistance to anthurium blight (Table 1). 'Lady Anne', a cross of *A. andraeanum* with *A. antioquiense,* was relatively susceptible to anthurium blight under field conditions (personal communication, Marian Osiecki, Oglesby Plants International, Altha, Fla.). The original cross was remade and 'Improved Lady Anne' was selected from the resulting progeny, indicating that genetic variability regarding *X. c.* pv. *dieffenbachiae* resistance may be present within a single hybrid population (Table 1). 'Crystal Hope' is an interspecific hybrid selection of *A. crystallinum* Linden & André that has small green flowers, dark velvety green leaves, and contrasting white veins. It will not hybridize with *A. andraeanum,* yet the attractive foliage of this cultivar has made it popular for use in interiorscapes. This cultivar exhibited great variability in susceptibility to the four isolates. Isolate X476 from Hawaii induced only mild chlorosis on the margins of leaves, while the other three isolates caused extensive damage to foliage.

As many isolates of the pathogen as possible should be tested from multiple locations in order to identify anthurium cultivars with broad resistance to *X. c.* pv. *dieffenbachiae.* The *dieffenbachiae* pathovar is very heterogeneous and is subdivided into two biotypes distinguished by their ability to hydrolyze starch. In Hawaiian anthurium cut-flower production, 62% of 177 isolates tested were unable to hydrolyze starch (Lipp et al., 1992). Diversity of this pathovar has been further demonstrated in studies of fatty acid profiles (Hodge et al., 1990), metabolic profiles (Chase et al., 1992), and monoclonal antibodies (Lipp et al., 1992). The starch-hydrolyzing biotype appears to produce symptoms more rapidly than the non-starch-hydrolyzing biotype, although no noticeable differences in disease severity were evident at the conclusion of the experiments. Although no information exists regarding the mechanism of action of bacterial blight resistance in anthurium, similar responses by closely related cultivars in this study indicate a probable genetic basis for resistance. These results will help in planning breeding programs whose goal is to produce anthurium hybrids resistant to *X. c.* pv. *dieffenbachiae.*

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