Cause and Control of Crown Rot of New Guinea Impatiens

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ABSTRACT

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Pythium ultimum and *Rhizoctonia solani* AG-4 each caused a similar crown rot of New Guinea impatiens growing in commercial greenhouses in New Jersey. *P. ultimum* caused a black moist rot while *R. solani* caused a drier brown rot and cracking of the infected tissue. The fungi were isolated from the crown of various diseased plants but not generally from stem sections above the crown. New Guinea impatiens cultivars showed a range of susceptibility to the disease caused by each organism. The cultivar Milky Way was most resistant and cultivars Aurora, Cosmos, and Twilight were the most susceptible to both fungi among the cultivars tested. PCNB controlled the *Rhizoctonia*-induced disease and metalaxyl and fosetyl-Al controlled the *Pythium*-induced disease.

New Guinea impatiens (NGI) have created considerable interest among commercial growers, gardeners, and plant breeders. The plants are the result of a hybridization program using plant material introduced from New Guinea in 1969 (1). Little published information is available on diseases and disease control in NGI. Only species of *Botrytis, Pythium, Rhizoctonia,* and *Phytophthora* have been reported as potential pathogens on NGI (6).

In a survey of NGI diseases, leaf blight, flower blight, and crown rot were the most common problems on greenhouse-grown plants. The blight symptoms were generally associated with infection by *Botrytis* spp. (Castillo and Peterson, *unpublished*). Rot was most common in rooted cuttings, where it was characterized by a blackening or browning and (at times) a cracking of the crown tissue. Depending on the cultivar, rot often advanced from the crown into the lower stem. Severely affected plants wilted and died (Fig. 1). Root rot was generally associated with severe crown rot symptoms. A superficial black streaking of the stem tissue above the crown occurred in some cultivars. Certain cultivars seemed to be more susceptible than others to this disease.

The objectives of this study were to determine the cause of the crown rot disease, distribution of the causal organism in the plant, and differences in disease susceptibility among selected cultivars; and to develop a suitable control measure for the disease.

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MATERIALS AND METHODS

Pathogen isolation and pathogenicity studies. Isolations were made from diseased NGI plants collected during a survey from several New Jersey commercial growers. Tissue sections were taken from stem bases, crowns, and roots; surface-sterilized for 2 min with a 0.525% sodium hypochlorite solution; and then incubated on potato-dextrose agar (PDA). An apple-baiting technique was used to isolate *Phytophthora* from diseased plant tissue (2). After being isolated, fungi were grown and stored on PDA slants for later identification.

We followed Koch's postulates in determining the pathogenicity of the fungal isolates. Agar-mycelium blocks (3 mm^2 each) were taken from the margin of actively growing fungal colonies and inserted into stem incisions on plants of NGI cultivars Nova and Red Planet. The wounds were then covered with moist cotton and wrapped with transparent tape. Four plants of each cultivar were inoculated with each isolate and incubated in the greenhouse for 7–10 days. Reisolations were then made using plant tissue adjacent to the inoculation point. Organisms that caused a disease were identified and used in subsequent experiments.

In additional inoculation experiments, fungus inoculum and a soilless mix consisting of peat, vermiculite, and perlite (6:6:4.5) were placed in a twin-shell blender and mixed for 10 min. A substratum for *Rhizoctonia* was prepared by placing millet (400 g) and distilled water (320 ml) into 2-L jars and autoclaving for 30 min at 15 psi on three successive days. For *Pythium,* a lima bean extract (50 g frozen lima beans boiled for 30 min, then filtered and mixed with distilled water to make 1 L) replaced the distilled water. Six-day-old cultures of *Pythium* or *Rhizoctonia* were cut into 1-mm^2 sections and mixed into the sterile millet in each jar. The resulting cultures were incubated at 25 C for 3 weeks. Four rooted cuttings each from Nova and Red Planet cultivars were planted into the *Pythium*- or *Rhizoctonia*-infested soilless mix (12 g inoculum per 120 g soilless mix). Control plants were grown in a noninfested soilless mix.

Distribution of the pathogen in the plant. To determine the movement of the fungi in the infected plants, four plants each from the cultivars Milky Way, Astro, and Nova were inoculated with either *P. ultimum* Trow or *R. solani* Kühn by growing the plants in infested soil as described above. Four noninoculated plants of each cultivar were included as controls. After three weeks, isolations were made from the crown and stem base, and from 2 and 4 cm up the stem.

Cultivar susceptibility. Thirteen NGI cultivars (Astro, Aurora, Columbia, Corona, Cosmos, Equinox, Gemini, Milky Way, Nova, Red Planet, Sunset, Twilight, and Twinkle) collected from commercial growers in New Jersey were tested for susceptibility to *Rhizoctonia* and *Pythium* isolates. Cuttings were taken from healthy mother plants that were originally derived from single plants, treated with 0.1% indoleacetic acid, and planted in soilless mix in cell starter packs. The plants were then kept under an intermittent mist system at approximately 27 C for 15 days.

Rooted cuttings were selected for uniformity and planted in 10.2-cm peat pots containing *Pythium*- or *Rhizoctonia*-infested soilless mix prepared as previously described. The most virulent isolates of *P. ultimum* and *R. solani,* as determined by preliminary pathogenicity tests, were used. Control plants were grown in the soilless mix without inoculum. Five plants per cultivar were used for each treatment; they were arranged in a completely randomized design in the greenhouse. After 25 days, the number of dead plants was recorded and the

remaining live plants were measured. Live plants were then harvested, placed in a drying oven at 72 C for three days, and weighed when dry. This experiment was repeated once.

Disease control with fungicides. Three fungicides were tested at various concentrations for their effectiveness in controlling diseases caused by *P. ultimum* and *R. solani* in NGI. The Astro cultivar was used as a test plant because of its moderate susceptibility to both fungi. Cuttings were rooted and plants were inoculated by growing them in the appropriate infested soilless mix. In the first test, PCNB was used to control *R. solani.* PCNB (Terraclor 75W) was applied as a drench at three concentrations (43, 85, and 170 g a.i. per 378 L) at 0.53 L sol per 9.3 dm^2. The second test used metalaxyl (Subdue 2E) and fosetyl-Al (Aliette 80W) to control *P. ultimum.* Fosetyl-Al was applied as a spray until runoff at four concentrations (0.9, 1.8, 2.7, and 3.6 kg a.i. per 378 L) and as a drench (0.7 kg a.i. per 378 L) at 0.7 L sol per 9.3 dm^2. Metalaxyl was applied as a drench at four concentrations (7.1, 14.2, 28.4, and 56.7 g a.i. per 378 L) at 0.53 L sol per 9.3 dm^2. All fungicide treatments were applied immediately after transplanting and again 4 wk later. The number of wilted and dead plants was noted and, after 8 wk, stem length was recorded for the living plants. These experiments were repeated once.

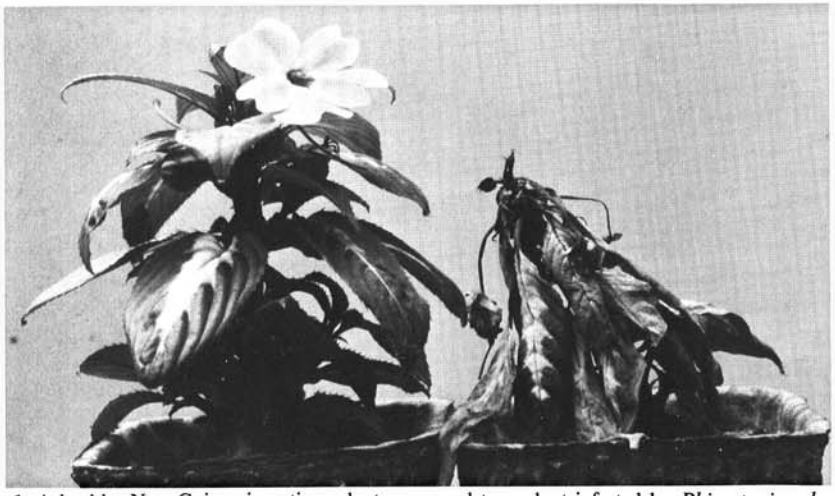

Fig. 1. A healthy New Guinea impatiens plant compared to a plant infected by *Rhizoctonia solani.*

Table 1. Pathogenicity of *Pythium ultimum* and *Rhizoctonia solani* on rooted cuttings of 13 New Guinea impatiens cultivars

	Pythium ultimum				*Rhizoctonia solani*		
Cultivar	Dry weight (g)	Stem length (cm)	Black streak length (cm)	Plant death (%)	Dry weight (g)	Stem length (cm)	Plant death (%)
Astro	0.06 ab[z]	1.9 abc	0.3 cd	40	0.08 cd	1.8 ab	60
Aurora	0.03 ab	0.6 bc	0.0 d	80	0.06 cd	1.5 ab	60
Columbia	0.13 a	2.5 ab	1.4 abc	20	0.13 bcd	2.7 ab	20
Corona	0.04 ab	1.3 abc	0.2 cd	60	0.12 bcd	3.0 ab	20
Cosmos	0.00 b	0.0 c	0.0 d	100	0.10 cd	2.1 ab	40
Equinox	0.08 ab	1.9 abc	0.2 cd	40	0.07 cd	2.0 ab	40
Gemini	0.06 ab	1.3 abc	1.1 bcd	60	0.32 a	3.8 a	0
Milky Way	0.11 a	3.1 a	2.4 a	0	0.24 ab	3.4 ab	0
Nova	0.04 ab	1.3 abc	0.0 d	60	0.03 d	1.2 b	60
Red Planet	0.13 a	2.8 a	0.7 cd	20	0.10 cd	2.9 ab	20
Sunset	0.07 ab	2.0 abc	1.3 abc	20	0.04 d	1.0 b	60
Twilight	0.00 b	0.0 c	0.0 d	100	0.18 bc	2.3 ab	40
Twinkle	0.11 a	2.6 ab	2.2 ab	20	0.18 bc	3.1 ab	20

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

Table 2. Control of Rhizoctonia root and crown rot in New Guinea impatiens using PCNB

Treatment	Rate (g a.i. per 378 L)[x]	Stem length (cm)[y]	Dead plants (%)
PCNB[z]	43	4.9 b	25
PCNB[z]	85	5.7 b	0
PCNB[z]	170	5.9 b	0
Control (inoculated)	···	··· c	100
Control (noninoculated)	···	10.2 a	0

[x]Drenches were applied at 0.53 L sol per 9.3 dm^2.
[y]Numbers in the same column followed by the same letter were not significantly different ($P = 0.05$) according to Duncan's multiple range test.
[z]Brand name Terraclor 75 WP.

RESULTS AND DISCUSSION

Isolation, identification, and symptomatology. In the survey, *Pythium* isolates were obtained mainly from diseased plant samples of the cultivars Astro, Comet, Cosmos, Gemini, Milky Way, Nova, and Red Planet. *Rhizoctonia* isolates were obtained mainly from the cultivars Corona, Gemini, Nova, and Telstar. In general, only *Pythium* or *Rhizoctonia* was isolated from a single diseased plant. Disease symptoms caused by either fungus on plants directly inoculated or grown in infested soil were similar to those observed on the original collected diseased plants. All plants inoculated with *Rhizoctonia* and *Pythium* became diseased.

Crown rot was usually the first symptom noticed when plants were grown in soilless mix infested with either fungus. The rotted tissue caused by *Pythium* infections was black and moist, and often extended into the basal stem. This contrasted with the drier brown rot and cracked tissue caused by *Rhizoctonia* infections. Superficial black streaks extending 5–7 cm up the stems were generally associated with *Pythium* infection, although this streaking was at times noted on plants infected with *Rhizoctonia* and on noninoculated plants. Generalized wilting, root rot, and death occurred in plants seriously affected by either fungus.

Pythium or *Rhizoctonia* were reisolated from all inoculated plants, thus satisfying Koch's postulates. The fungi were constantly isolated from the original diseased plants and, based on these tests, five isolates of *Pythium* and three isolates of *Rhizoctonia* were collected. *Phytophthora* was not isolated from any plants.

The *Pythium* isolates grown on various selective media (3,4,6) to induce reproductive structures were all identified as *P. ultimum* Trow (4,7). The *Rhizoctonia* isolates were identified as *R. solani* Kühn AG-4 according to the methods of Parmeter et al (5) and by using anastomosis group testers AG-1, AG-2, AG-3, and AG-4. Either *P. ultimum* or *R. solani* AG-4 were associated with crown rot of NGI growing in New Jersey and were generally responsible for this disease in commercial plantings.

Distribution of the pathogens in the plant. *R. solani* and *P. ultimum* were isolated from necrotic tissue in the crown area and lower stem but not from stem sections above the necrotic tissue.

Table 3. Control of Pythium root and crown rot in New Guinea impatiens with fosetyl-Al and metalaxyl

Treatment	Method	Rate (a.i. per 378 L)	Stem length (cm)[u]	Dead plants (%)
Fosetyl-Al[v]	Spray[w]	0.9 kg	5.0 ab	50
Fosetyl-Al[v]	Spray[w]	1.8 kg	5.3 ab	0
Fosetyl-Al[v]	Spray[w]	2.7 kg	5.5 ab	0
Fosetyl-Al[v]	Spray[w]	3.6 kg	5.0 ab	0
Fosetyl-Al[v]	Drench[x]	0.7 kg	5.8 ab	0
Metalaxyl[y]	Drench[z]	7.1 g	6.2 a	0
Metalaxyl[y]	Drench[z]	14.2 g	5.9 a	0
Metalaxyl[y]	Drench[z]	28.4 g	6.0 a	0
Metalaxyl[y]	Drench[z]	56.7 g	4.9 b	0
Control (inoculated)	...	...	1.4 c	75
Control (noninoculated)	...	...	6.5 a	0

[u] Numbers in the same column followed by the same letter were not significantly different ($P = 0.05$) according to Duncan's multiple range test.
[v] Brand name Aliette 80WP.
[w] Applied until runoff.
[x] Applied at 0.7 L sol a.i. per 9.3 dm^2.
[y] Brand name Subdue 2E.
[z] Applied at 0.53 L sol a.i. per 9.3 dm^2.

Neither fungus was isolated from the noninoculated control plants. Basal stem lesions and black stem streaking were more common in *P. ultimum*-inoculated plants than in *R. solani*-inoculated plants. The black streaking was superficial in the tissue and often extended up the stem. At times certain noninoculated plants developed the characteristic black streaking; however, neither fungus was isolated from these blackened areas.

P. ultimum and *R. solani* were localized in the crown region primarily at or just below the soil level. This was true both in plants used in the inoculation test and in diseased plants collected from commercial growers. *P. ultimum* in particular could at times be found in roots below this level. Fungi were not isolated from the upper stem areas of larger infected mother plants used for cutting purposes.

Crown and basal stem rot lesions were more extensive in infections caused by *P. ultimum* than in those caused by *R. solani* . With both fungi, however, the rot did not extend far up the stem. These results suggest that the two fungi initially entered the stem wound during rooting or soon after the cuttings were transplanted. The fungi then invaded the crown area but did not move up the stem. Consequently, transmission of the disease directly through cuttings taken from mother plants is not likely. Although black stem streaking can occur in uninfected plants, the presence of *P. ultimum* can enhance this streaking. The fungus was not isolated when black streaking occurred in the upper stem parts, but *P. ultimum* was usually isolated from streaks near the crown. It is possible that the black streaking is a hypersensitive response to the fungus infection or that it is caused by another root or crown disorder. More experimentation is needed to determine the cause of the stem streaking.

Cultivar susceptibility. Because cultivar susceptibilities to both pathogens were essentially the same in both experiments, only data from the second experiment are given in Table 1.

The NGI cultivars varied in their susceptibility to the *P. ultimum* isolates (Table 1). None of the noninoculated plants had crown rot or black streaks on their stems. The occurrence and extent of black streaking varied among the inoculated plants and did not correlate with the resistance pattern of the rooted cuttings. Little size variation occurred among noninoculated plants in a given cultivar. All Milky Way plants showed some crown necrosis but none died. The occurrence of crown necrosis and death in Columbia, Red Planet, Sunset, and Twinkle plants was lower than in other cultivars tested. These plants did, however, exhibit the characteristic black stem streaking. All Cosmos and Twilight plants in this experiment died.

Differences in susceptibility among cultivars inoculated with *R. solani* are also shown in Table 1. Little or no black streaking occurred in the *Rhizoctonia*-inoculated plants. Inoculated plants of the cultivars Gemini and Milky Way were larger than inoculated Astro, Aurora, Nova, and Sunset plants. Gemini and Milky Way plants generally did not die; Astro, Aurora, Nova, and Sunset cultivars had a greater number of deaths.

Plants inoculated with *P. ultimum* and *R. solani* were generally smaller and weighed less than corresponding noninoculated control plants. Aurora, Cosmos and Twilight were most susceptible to the crown rot disease in general; Milky Way was most resistant to both pathogens. Certain cultivars were more resistant to one pathogen or the other. Although none of the cultivars were free of crown rot, there was a wide range of susceptibility to the disease. Based on these differences, growers are avoiding the use of certain NGI cultivars for commercial production.

Disease control with fungicides. The data summarized in Table 2 and Table 3 are the results from the first disease control experiments. Disease data from the other experiment were essentially the same and are not presented.

PCNB readily controlled the *R. solani* disease at concentrations of 85 and 170 g a.i. per 378 L. There were no plant deaths at either of these levels or in the noninoculated control treatment. Plant growth (as measured by stem length) was significantly less in plants under the PCNB treatments than in the nontreated, noninoculated plants (Table 2).

Metalaxyl and fosetyl-Al were both effective in controlling *P. ultimum*. There were no plant deaths under any of the four metalaxyl treatments, which ranged from 7.1 to 56.7 g a.i. per 378 L (Table 3). With fosetyl-Al, both drench treatment (7.1 g a.i. per 378 L) and spray treatment at the three higher levels (1.8, 2.7, and 3.6 kg a.i. per 378 L) controlled the fungus. However, plants treated with fosetyl-Al were somewhat smaller than nontreated, noninoculated plants.

Disease control was significantly better on plants receiving any of the chemical treatments than on the inoculated, nontreated control plants. Crown rot was evident in dead plants regardless of the fungicide used.

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