Basal Stem and Root Rot of Christmas Cactus Caused by Phytophthora parasitica

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ABSTRACT

A new and potentially serious disease has recently been observed affecting Christmas cactus (*Zygocactus truncatus*). The first symptoms occur as a wilting of stems which exhibit a lifeless, dull, gray-green color. The basal portion of the affected stems, usually at or just below the soil line, reveals a water-soaked but rather firm necrotic area with a faded reddish border. Infected roots are water-soaked, brown, soft, and necrotic. Repeated isolations from affected stems and roots of naturally infected plants, and results of controlled inoculations with a single isolate, have shown that *Phytophthora parasitica* is the causal agent. Among four fungicides tested for disease control as a soil drench prior to inoculation, Dithane M-45 (coordination product of zinc ion and manganese ethylene bisdithiocarbamate) provided complete control, and Dexon [*p*-(dimethylamino) benzenediazo sodium sulfonate], very good control; whereas Terrazole (5-ethoxy-3-trichloromethyl-1,4-thiadiazole) and Demosan (1,4-dichloro-2,5-dimethoxybenzene) provided the least effective disease control. Phytopathology 61:804-806.

Additional key words: Phycomycetes, chemical control.

Christmas cactus, *Zygocactus truncatus* Schum., is a member of the family Cactaceae. It lacks the characteristic spines usually associated with the family, and is grown as an ornamental primarily for its showy flowers. Its stems are made up of segments of phylloclades which lend themselves readily to vegetative propagation.

During the summer of 1969, a noticeable wilting of a few stems of potted greenhouse-grown Christmas cactus was observed among well-established stock plants (3). Affected stems appeared lifeless, having a dull, gray-green color, drooped much more severely than the gracefully arched healthy stems (Fig. 1-D), and were limp due to a loss of turgor. Such stems on occasion were observed to display abnormal abscission of some phylloclades by a disjunction of the terminal two to three phylloclades. A close examination of affected plants revealed a basal stem rot, usually at or just below the soil line. The necrosis was water-soaked, rather firm, and frequently delimited by an undulated, faded reddish border. Roots from affected stems were brown, soft, water-soaked, and necrotic. Isolations from stems and roots consistently yielded *Phytophthora parasitica* Dast.

Phytophthora parasitica is well documented as a destructive pathogen, and is known to have an extensive host range (11) encompassing 72 genera in 42 families of flowering plants (6). It is increasingly becoming one of the most serious soil-borne phycomycetous fungus pathogens in Florida.

MATERIALS AND METHODS.—Experimental plants included unrooted cuttings and young established plants of Christmas cactus. Unrooted cuttings consisted of the terminal two to three phylloclades taken from healthy stock plants and immediately placed in 4-inch clay pots, three/pot. Established plants also consisted of the terminal two to three phylloclades which were rooted and transplanted to 4-inch clay pots, three/pot. Sterilized greenhouse potting medium (1 part sand to 1 part peat) was used throughout the experiment. All potted plants and cuttings were maintained on a greenhouse bench and placed in clay saucers which were kept half full with deionized tap water in order to provide opt conditions conducive to disease development by phycomycetous fungi. During the pathogenicity trial with established plants of *Zygocactus*, greenhouse temperatures ranged from 21 to 32 C during the day and from 9 to 18 C during the night, whereas during the trial with unrooted cuttings the temperature ranged from 18 to 29 C during the day and 13 to 21 C during the night.

All experimental inoculations were made with an isolate of *P. parasitica* secured from a naturally infected plant of *Z. truncatus*. The culture was grown on hemp agar (HA = 40 ml hemp seed extract, 20 g Difco agar/liter), since this medium favors sporangial production. A pinch of Bentonite, a colloidal clay which aids in reducing metallic ion toxicity, was added to the sterile tap water prior to preparation of inoculum.

Thirty-six unrooted cuttings of Christmas cactus contained in 12 pots were inoculated with 100 ml of inoculum/pot. Inoculum was prepared from eight petri plates of 16-day-old cultures which were flooded with sterile tap water 24 hr prior to a 30-sec comminution in a blender. Flooding the cultures enhanced the production of zoospores. Sterile tap water was added to make up a final inoculum of 1,200 ml. The same number of cuttings were used as controls and were treated similarly, except that they received HA minus the test fungus. Following inoculation, ca. 1 cm of sterilized soil was applied to the soil surface of each pot. Thirty established plants were inoculated in a like manner.

Four fungicides were tested for efficacy of plant disease control on established plants. These were Dithane

M-45 80 WP (coordination product of zinc ion and manganese ethylene bisdithiocarbamate) Rohm and Haas, applied at the rate of 2.2 g/liter; Dexon 35 WP [*p*-(dimethylamino) benzenediazo sodium sulfonate], Chemagro Corporation, at 2.2 g/liter; Terrazole 35 WP (5-ethoxy-3-trichloromethyl-1,4-thiadiazole), Olin Mathieson Chemical Corporation at 0.8 g/liter; and Demosan 65 WP (1,4-dichloro-2,5-dimethoxybenzene) Du Pont, at 1 g/liter. Thirty plants were used in each treatment. All pots received 75 ml each of the respective fungicide applied as a soil drench 24 hr before inoculation. Controls consisted of the same number of plants which were inoculated but received no fungicide, as well as control plants which received fungicides but no inoculum. The latter group of control plants was established in order to observe any possible indication of phytotoxicity attributable to the test chemicals incorporated for disease control.

In addition to tomato plants (2, 4, 8), *Lycopersicon esculentum* Mill. 'Manalucie' and 'Walter'; large, unripe tomato fruits; papaya (9), *Carica papaya* L.; garden petunia (7, 10), *Petunia hybrida* Vilm. 'Bingo' and 'Pink Satin'; and *Bougainvillea* (1, 2) 'Barbara Karst' and 'Gold' as established hosts of *P. parasitica,* a diverse group of ornamental plants were included in a host range susceptibility study.

All plants tested for host range susceptibility were spray-inoculated with inoculum prepared as above, immediately covered with polyethylene bags, and placed in a plant growth chamber at 30 C, 95% relative humidity, with 12 hr of 5,000 ft-c of light and 12 hr of darkness. In addition, seedling tomato plants were inoculated by pouring inoculum onto the soil at the base of potted plants. Unripe tomato fruits were inoculated by placing a small spherical mass of absorbent cotton which had been dipped into the inoculum on the surface of the fruit. The fruits were placed on a wire rack in a moist chamber. The moist chambers were placed in the plant growth chamber.

RESULTS.—On the 36 inoculated unrooted cuttings, the first visible symptoms of infection occurred in 2 days as small, water-soaked spots on the stems at the soil line (Fig. 1-A). In 4 days, the basal infection had encompassed the width of the stem, extending ca. 2 cm above and below the soil line (Fig. 1-B), and terminal phylloclades had abscised (Fig. 1-C). Infection was delimited by a faded, reddish-brown discoloration at the periphery of the hydrosis, and finally, complete collapse of the cutting took place in an additional 2 to 3 days. *Phytophthora parasitica* was not recovered from the tissue at the site of abscission of the terminal phylloclades. Infection occurred in 35 of the 36 unrooted cuttings, based upon successful recovery of the test fungus from the lowermost phylloclad. Cuttings in the control treatment remained unaffected throughout the course of this trial.

The first visible symptoms of infection occurred in 7 days among the 30 inoculated established plants. Initial infection took place at the soil line with symptoms similar to those expressed with unrooted cuttings. Terminal phylloclades also abscised. Roots of infected

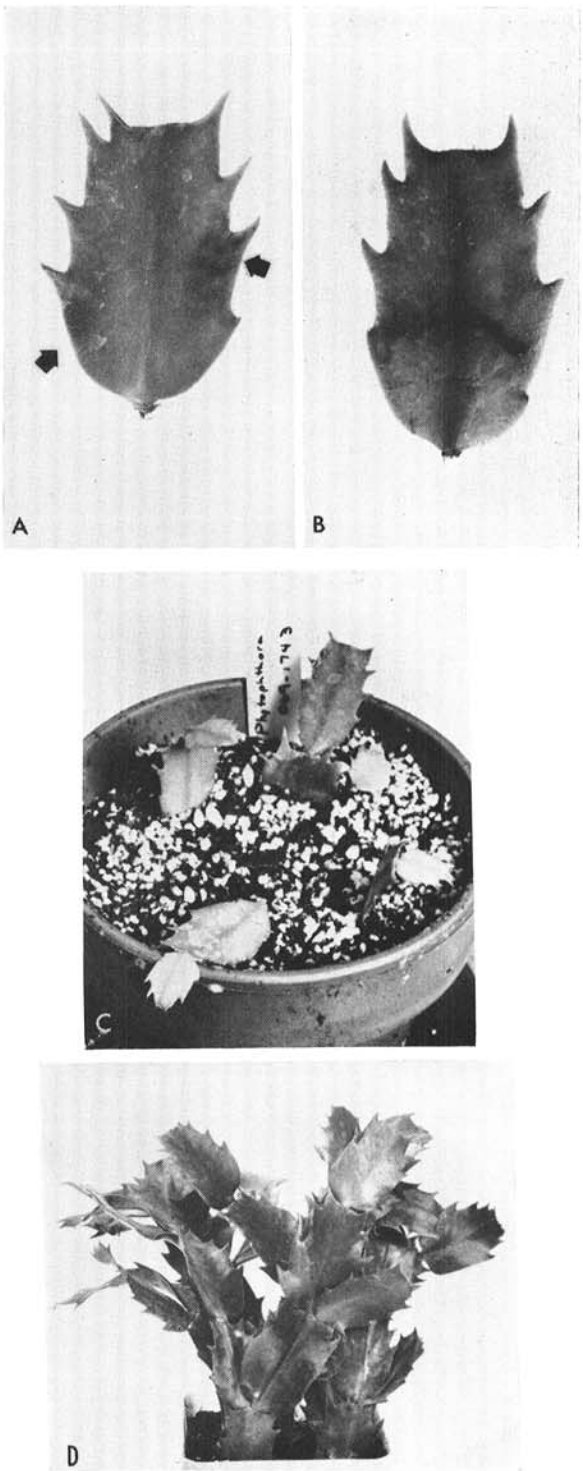

Fig. 1. Infection of *Zygocactus truncatus* by *Phytophthora parasitica:* **A)** initial water-soaked spots on basal stem; **B)** advanced necrosis of basal stem with reddish brown margin; **C)** abscission of terminal phylloclades; **D)** healthy plant.

plants were brown, soft, water-soaked, and necrotic. Thirteen of the 30 inoculated plants were infected, whereas the plants in the controls remained unaffected.

The results of four fungicides tested for efficacy of disease control on established plants of *Z. truncatus,* indicated by the number of plants infected over the total number of plants inoculated, were as follows: Dithane M-45 0/30; Dexon 1/30; Terrazole 6/30; Demosan 11/30; whereas the inoculated controls were 13/30. In this regard, Dithane M-45 gave complete control, and Dexon very good control, whereas Terrazole and Demosan provided the least effective disease control. In conjunction with the trial on fungicidal efficacy, control groups of 15 established plants treated with each of the four fungicides for indication of chemical injury showed no evidence of phytotoxicity.

As a result of the host range susceptibility study, the following plants were found susceptible to this isolate of *P. parasitica: Lycopersicon esculentum* 'Manalucie' and 'Walter'; *Petunia hybrida* 'Bingo' and 'Pink Satin'; *Ajuga reptans* L.; *Calendula officinalis* L.; and *Bougainvillea* cultivar 'Gold'. Nonsusceptible hosts were green, unripe tomato fruits: *Carica papaya; Bougainvillea* cultivar 'Barbara Karst'; *Aglaonema modestum* Schott; *Aloe vera* L.; *Ardisia crenata* Sims; *Brassaia actinophylla* F. Muell.; *Carissa grandiflora* DC.; *Chamadorea elegans* Leebm.; *Chrysanthemum morifolium* (Ramat.) Hemsl.; *Clerodendrum bungei* Stend.; *Dichorisandra reginae* (L. Linden & Rodigas) W. Ludw.; *Dieffenbachia picta* Schott; *Euonymus japonicus* L.; *Gerbera jamesonii* Bolus; *Gynura aurantica* DC.; *Ixora coccinea* L.; *Pelargonium hortorum* Bailey; *Peperomia obtusifolia* A. Dietr.; *Philodendron oxycardium* Schott; *Setcreasea purpurea* Boom; and *Zebrina pendula* Schnizl.

Essentially, the symptoms on the leaves of susceptible plants of seedling tomato, *Ajuga* and *Calendula,* were the same. The leaf spots occurred in 3 to 5 days as water-soaked, grayish-green areas of collapsed tissue, usually (but not always) at the margins. The spots rapidly increased in size, and became dark green to black as the entire leaf became infected and collapsed. Spray-inoculated tomato plants succumbed in 6 days, and *Ajuga* and *Calendula* in 9 to 10 days. On the other hand, tomato plants inoculated with fungus inoculum poured onto the soil at the base of the plant, and inoculated, unripe, green tomato fruits did not become infected.

DISCUSSION.—The isolate of *P. parasitica* used in this work is highly pathogenic to both unrooted cuttings and established plants of *Z. truncatus,* to seedling tomato plants, and to two new hosts, *Ajuga reptans* and *Calendula officinalis.* This isolate of *P. parasitica* was nonpathogenic to tomato fruits, *Bougainvillea* 'Barbara Karst', and papaya, and slightly pathogenic to petunia and *Bougainvillea* 'Gold', which indicates the possible existence of physiologic races of this pathogen as suggested by Haasis (5). While Daconil 2787 75 WP (tetrachloroisophthalonitrile) Diamond Shamrock is effective against foliage blight caused by this fungus (1, 2), the results of the fungicide trial for control of *P. parasitica* as a stem and root pathogen showed that disease control can be effected with the use of other fungicides as soil drenches.

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