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Phytophthora Diseases of Ornamental Plants in Araceae in Taiwan

Pao-Jen Ann

Chia-yi Agricultural Experiment Station, Chia-yi, Taiwan, R.O.C.
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ABSTRACT

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Phytophthora diseases of ornamental plants in the family of Araceae were surveyed in Taiwan from 1988 to 1991. Two species of *Phytophthora* were detected from diseased tissues of five different genus of ornamental plants. All affected plants were with leaf blight; some of them wilted and died due to severe stem or root rot. The species of *Phytophthora* isolated from the infected plants were *P. meadii* on *Aglaonema nitidum* (Jacq.) Kunth cv. *"Curtisii"*, and *P. parasitica* on *Aglaonema commutatum*, *Anthurium andreanum*, *Dieffenbachia maculata*, *Epipremnum aureum*, and *Philodendron* spp. In pathogenicity tests, each species of *Phytophthora* produced disease symptoms on their respective host plants similar to those occurring in natural field condition. The pathogen, *P. meadii* was first discovered in Taiwan. All Phytophthora diseases of ornamental plants in Araceae were first reported in Taiwan. Meanwhile, *P. parasitica* and *P. meadii* on *Aglaonema* spp, and *P. parasitica* on *A. andreanum* and *E. aureum*, were first documented in the world.

Key words: Ornamental plants, Araceae, *Aglaonema nitidum*, *Aglaonema commutatum*, *Anthurium andreanum*, *Epipremnum aureum*, *Philodendron* spp, *Phytophthora meadii*, *Phytophthora parasitica*.

INTRODUCTION

Ornamental plants have become important economic commodity in Taiwan in recent years due to improve economic standard. Currently, there are many varieties of ornamental plants grown in fields or in green houses distributed through the entire island; however, majority of the ornamental crops are grown in the central counties. Diseases caused by *Phytophthora* species are especially serious in Taiwan (1,4,6,8) because of frequent heavy rainfall which is favorable to the spread of sporangia and zoospores in the fields, and the lack of cold temperature during the winter necessary to kill the pathogens. Moreover, recycling culture media without or incomplete pasteurization is another primary factor for the high disease incidence each year.

Species of *Phytophthora* have been recorded to be pathogenic to many ornamental plants throughout the world. However, *Phytophthora parasitica* Dastur and *Phytophthora palmivora* (Butler) Butler are two of the most destructive (7). Previously, diseases of ornamental foliage plants caused by *Phytophthora* species have not been studied in Taiwan. Therefore, a survey was conducted from 1988 to 1991. I report herein the identity of the *Phytophthora* species isolated from diseased tissues of ornamental plants in the family of Araceae grown in pots in green houses or planted directly in the ground. Pathogenicity of the isolated *Phytophthora* to their respective host plants was also studied. A brief report of parts of this work has been published in 1990 (3).

MATERIALS AND METHODS

Isolation

Diseased tissues of the ornamental plants in Araceae were collected from green houses or natural fields. Pieces of tissues taken from leaves (*ca.* 5 × 5 mm), stems or roots (*ca.* 5–10 mm long) with advanced blight symptoms were disinfested with 0.5% NaClO for 3 min. The treated tissues were plated onto selective medium at 24 C for one to seven days. Selective medium consisting of 5% clarified V-8 juice agar (5% V-8 juice plus 0.2% $CaCO_3$ centrifuged at 1500 rpm for 5 min and 2% Bacto agar) was supplemented with 200 ppm Ampicillin, 50 ppm mycostatin, and 10 ppm pentachloronitrobenzene (PCNB) (17). After incubation at 24 C for 1–2 days, mycelial mats of *Phytophthora* spp. growing out of diseased tissues on selective medium were transferred to 5% clarified V-8 juice

agar. For preparation of single-zoospore cultures, a small piece of mycelial agar block (*ca.* 5 × 5 × 3 mm) grown on 5% V-8 juice agar was placed in a small Petri dish (60 mm in diameter) containing 10 ml of sterile distilled water. After incubation at 24 C under light for 24 hr for sporangial formation, the cultures were placed at 15 C for 30 min and returned to 24 C for development and discharge of zoospores (14). A drop of zoospore suspension was spread on a plate of water agar. After 24 hr, individual germinating zoospores were transferred to 5% V-8 juice agar plates. Single-zoospore isolates were used for these studies and maintained on 5% V-8 juice agar blocks in sterile water in test tubes at 24 C (5).

Production of sporangia and zoospores

The method described by Hwang *et al* (10) was used for production of large amount of sporangia for morphological studies and pathogenicity tests. Zoospore suspension was prepared by chilling the mycelial mats with sporangia at 15 C for 30 min followed by returning them to 24 C for 30 min. The suspension was passed through two layers of cheesecloth to remove the mycelia before being used for inoculation.

Determination of mating types

Each isolate of *Phytophthora* was grown on 10% V-8 juice agar (10% V-8 juice, 0.02% $CaCO_3$, 2% Bacto agar) at 24 C in darkness for 10 days. Those individual isolates producing oospores independent of each other under such conditions were considered to be homothallic and all others were either heterothallic or sterile. Isolates which did not form oospores were paired with the standard A^1 (p991) and A^2 (p731) mating type of *P. parasitica* individually for determination of their mating types. A small piece of culture block (*ca.* 2 × 2 × 2 mm) of each isolate and tester were placed on opposing ends on a piece of 10% V-8 agar (*ca.* 15 × 10 × 2 mm) in Petri dishes (100 mm diam). Eight pieces of agar blocks were placed at equal distance along the perimeter of a Petri dish (2). After incubation at 24 C in darkness for 6 days, agar blocks were examined microscopically. Those isolates forming oospores when paired with the A^2 tester were designated as A^1. Similarly those forming oospores with A^1 tester were A^2, and those forming oospores with both A^1 and A^2 testers were A^1A^2. Those that failed to form oospores when paired with either A^1 or A^2 tester were designated as A^0 (sterile).

Production of oospores

The polycarbonate membrane method described by Ko (12) was used for sexual reproduction of heterothallic *Phytophthora* spp. Each isolate was grown on 10% V-8 agar block (20 × 15 × 3 mm) in a small Petri dish and kept in a moist chamber. After incubation at 24 C in darkness for 6 days, the culture block was transferred into the center of a sterile Petri dish and aseptically covered with a sterile polycarbonate membrane (0.2 μm, 90 mm diam.; Nucleopore, Pleasanton, CA 94566, USA). The mycelial surface of an 1-day-old culture block of a standard isolate with opposite mating type to serve as the hormone producer was placed upside down onto the polycarbonate membrane and superimposed onto the lower agar block. The polycarbonate membranes were used to prevent direct contact of the two pairing cultures. After incubation in the same environmental conditions for another 6 days, presence of oospores on the surface of the lower agar blocks was examined microscopically.

Growth of *Phytophthora*

Phytophthora isolates were grown on 5% clarified V-8 juice agar for 3–5 days. Agar discs (5 mm in diameter) that were cut from the periphery of the colonies with a sterile cork borer were used as inoculum to inoculate plates. One agar disc inoculum was transferred onto the edge of each 5% clarified V-8 agar plate. To determine the effect of temperature on the growth of each *Phytophthora* spp., inoculated agar plates were incubated at 10, 12, 15, 18, 21, 24, 27, 30, 33, 36 and 38 C in darkness. Colonies were measured daily until the mycelia reached the opposite edge of the plates or 10 days after inoculation. Four plates were used for each temperature and the experiment was repeated twice.

Identification

Classification Keys (Stamps *et al* (20), Waterhouse (23)) and original descriptions (24) were used for identification of the *Phytophthora* isolates obtained. Morphological and physiological characteristics of each culture were compared with those described in taxonomy papers.

Pathogenicity tests

One or two isolates per *Phytophthora* species obtained from each host plant were selected for pathogenicity tests. Zoospore suspension used as inoculum was adjusted to 10^5–10^6 zoospores/ml with the micrometer syringe method (16). One seedling per pot (12 × 12 × 12 cm) was grown in pathogen-free soil in a green house. Roots were inoculated by dispensing 10 ml of zoospore suspension on to the soil surface of each pot. Five seedlings were inoculated for each treatment and tests were repeated twice. Leaves were inoculated by spraying the zoospore suspension on to the whole plants until dripping of zoospore suspension occurred with the aid of an atomizer. Inoculated test plants were enclosed in transparent plastic bags (50 μm thick) to maintain moisture for two days. Two seedlings were used for each treatment. Controls for each test were similarly treated with distilled water. After incubation at 24 C for 3 days, disease incidence was rated every 3 days. The diseased tissues were sampled, disinfested with 0.5% NaClO for 3 min and plated on selective medium to confirm pathogenicity of each candidate microorganism.

RESULTS

Ornamental plants infected with *Phytophthora* spp.

Phytophthora were detected from diseased tissues of *Aglaonema commutatum* Schott (aglaonema), *Aglaonema nitidum* (Jacq.) Kunth cv. *"Curtisii"*, *Anthurium andreanum* Linden (anthurium), *Dieffenbachia maculata* Don (dieffenbachia), *Epipremnum aureum* Bunt. (pothos vine), and *Philodendron* spp. in this survey. The host plants, infection sites and species of *Phytophthora* obtained are listed in Table 1. Disease symptoms of some important ornamental plants of Araceae are shown on Fig. 1.

Aglaonema (粗肋草)

Phytophthora meadii McRae was isolated from the leaves of one variety of *Aglaonema nitidum* (亮葉粗肋草) in Teinwei, Changhua. The fungus produced large black spots (3–5 cm diam.) on older leaves and petioles (Fig. 1A). The affected leaves became yellowing in a few days. Eventually the diseased leaves rotted and drooped. On younger leaves the same pathogen produced tiny water soaked spots (*ca.* 2–5 mm). All 5 isolates of *P. meadii* obtained were determined to be A^2 mating type.

P. parasitica attacked leaves and petioles of *A. commutatum* "Silver queen". Two A^1 isolates were obtained from diseased leaves of aglaonema. The fungus caused leaf tip blight (Fig. 1B), marginal blotch or petiole blight on mature leaves of aglaonema. The infected portions of the leaves appeared yellowish with water soaked discoloration and eventually the affected leaves rotted and fell. Usually the fungus entered aglaonema from leaf tips or through wounds.

Anthurium (火鶴花)

Phytophthora mainly attacked mature and older leaves of anthurium plants. Initially, the infected leaves were with irregular light brown spots and turned to darker brown (1–5 cm diam.) after 2–3 days (Fig. 1C). Occasionally, the fungus caused shoot blight and stem rot; eventually the end result was death to the whole plants. A total of 15 isolates of *P. parasitica* were isolated from 5 different anthurium fields. All of them belonged to A^2 mating type.

Dieffenbachia (萬年青)

P. parasitica attacked the whole plants of several varieties of *D. maculata*, including Hawaii Snow (白玉) and Rudolph Roehrs (白葉). The affected leaves were with large water soaked spots (*ca* 3–10 cm diam.) and wilt and droop after 3–5 days (Fig. 1D). The plants eventually died when the stems or main root were infected with the fungus. Eight A^2 isolates of *P. parasitica* were obtained from diseased stem and leaves.

E. aureum (黃金葛)

Phytophthora foliage disease of pothos vine in Taiwan was very serious. Usually *Phytophthora* attacked leaves, petioles, and stems (vines) of this plant. Infected leaves became brownish black, droopy, and fell in a few days (Fig. 1E). The stems, especially the areas to which the vine coils itself to a support, were frequently attacked by *Phytophthora*; and above the infected sites eventually died. The pathogen also caused root rot. Four isolates (2 A^1 : 2 A^2) of *P. parasitica* were obtained from diseased leaves. Meanwhile, both A^1 and A^2 isolates of the same fungus were isolated simultaneously from the same diseased pothos vine from the field.

Philodendron (蔓綠絨)

A total of 13 isolates (8 A^1 : 5 A^2) of *P. parasitica* were isolated from diseased leaves of several varieties (帝王、紅公主、粉彩、Tuxla, etc) of *Philodendron* species. Both A^1 and A^2 mating type isolates were also detected in two of four philodendron fields. *Phytophthora* attacked

TABLE 1. Isolation of *Phytophthora* from ornamental plants in the family of Araceae in Taiwan

Name of host		Infected sites	*Phytophthora* species	No. of isolates obtained	Location
Scientific	Chinese				
Aglaonema commutatum	粗肋草(銀后)	leaves & petioles	*P. parasitica*	2 A^1 : 0 A^2	Changhua
Aglaonema nitidum	粗肋草(亮葉)	Leaves & petioles	*P. meadii*	0 A^1 : 5 A^2	Changhua
Anthurium andreanum	火鶴花	Leaves, buds & stems	*P. parasitica*	0 A^1 : 15 A^2	Chiayi, Yunlin, Taitung
Dieffenbachia maculata	萬年青(白玉、白葉)	Whole plants	*P. parasitica*	0 A^1 : 8 A^2	Changhua, Taitung
Epipremnum aureum	黃金葛	Whole plants	*P. parasitica*	2 A^1 : 2 A^2	Changhua
Philodendron spp.	蔓綠絨	Leaves or whole plant	*P. parasitica*	8 A^1 : 5 A^2	Changhua

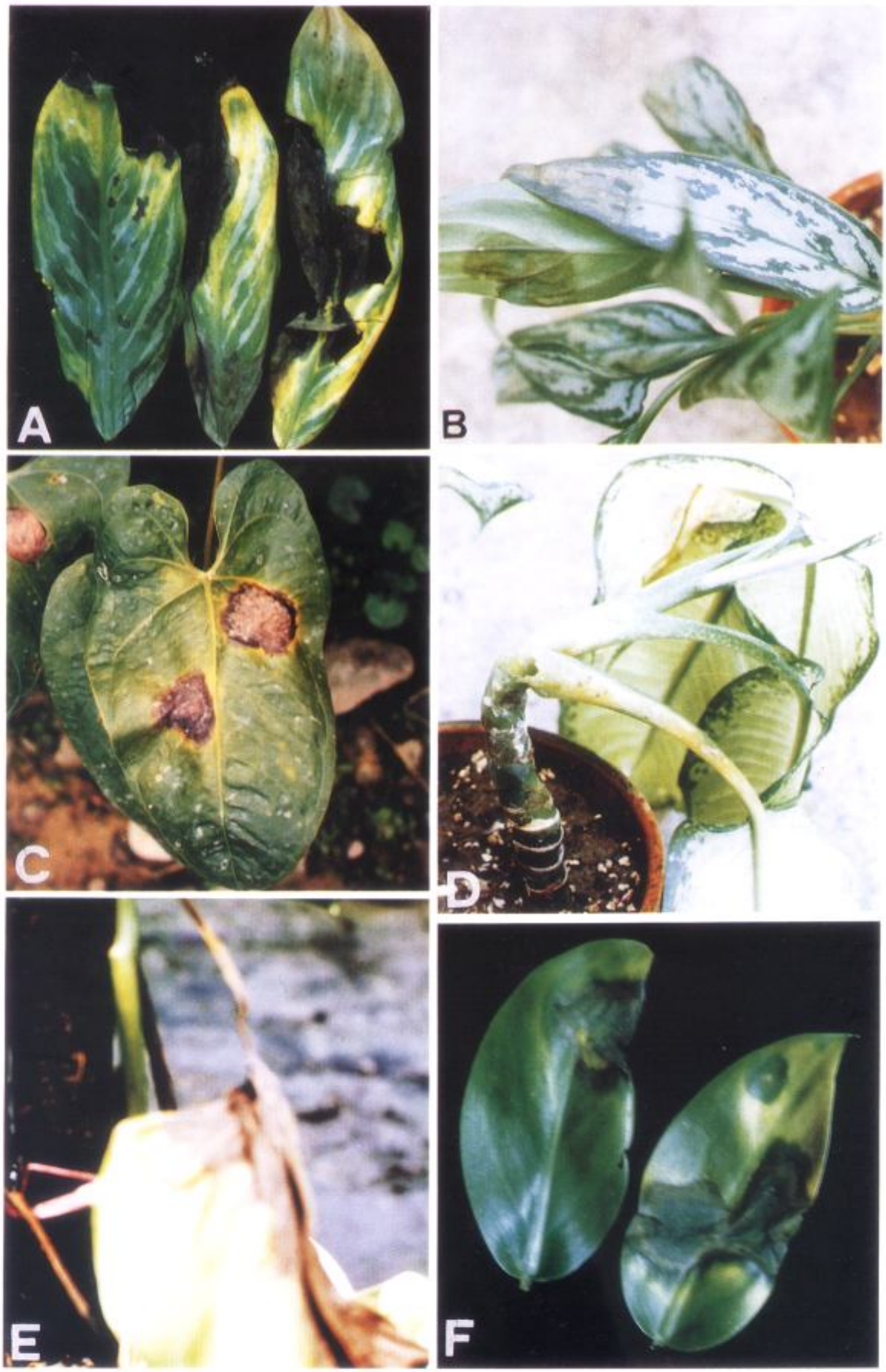

Fig. 1. Disease symptoms on (A) *Aglaonema nitidum* infected with *Phytophthora meadii*; and (B) *A. commutatum*, (C) *Anthurium andreanum*, (D) *Dieffenbachia maculata*, (E) *Epipremnum aureum*, and (F) *Philodendron* sp. infected with *P. parasitica*.

leaves, petioles, and aerial roots of philodendron. Infected leaves and petioles were with bleached-out water soaked spots (2–3 cm diam.). The affected leaves eventually turned yellow and abscised (Fig. 1F). Infected aerial roots were brownish and turned necrotic.

Characteristics of *Phytophthora* spp.

One or two isolates of *Phytophthora* obtained from each host plant were selected for study. Isolates of *P. parasitica* from aglaonema, anthurium, dieffenbachia, philodendron and pothos vine, and *P. meadii* from aglaonema were studied.

Isolates of *P. parasitica* from Araceae produced spherical chlamydospores and few sporangia on 5% V-8 agar medium at 24 C under light, while *P. meadii* formed abundant chlamydospores and sporangia under the same cultural conditions. However, large amount of sporangia from isolates of both *Phytophthora* species were produced on mycelial mats using the method developed by Hwang *et al* (10). The shape and size of sporangia varied significantly between the two species but not within the same species.

Isolates of *P. parasitica* from aglaonema, anthurium, philodendron, and pothos vine produced sporangia that were spherical or ovoid, papillate, and nondeciduous; average range of length and width was 36.8–55.6 × 30–42.8 μm (Table 2). Some sporangia of the fungus were with two papilla. The sporangia from tested isolates of *P. parasitica* from dieffenbachia were longer, having a larger L/W (length/width of sporangia) ratios (*av.* 1.51) than those *P. parasitica* from other Araceae (*av.* 1.2–1.3) (Fig. 2A,B; Table 2). The size of sporangia from dieffenbachia was measured to have a range of 41–80 × 29–55 μm (*av.* 60.3 × 40.2 μm).

The shape and size of sporangia produced by *P. meadii* from aglaonema in Taiwan were similar to those of standard *P. palmivora*. They were ovoid, obpyriform or ellipsoid, papillate, deciduous, born sympodially and having a length to width range of 55–120 × 29–85 μm (*av.* 80.5 × 42.5 μm) (Fig. 2C,D; Table 2). However the length of the pedicels of the fungus which measured 5–20 μm (*av.* 10.3 μm) was much longer than those of *P. palmivora*, that usually measures about 2–5 μm (20,22,24). Meanwhile, a few sporangia from aglaonema were with unusual shape or having 2 papilla.

All tested isolates of ornamental plants in Araceae belong to cross-inducing (Heterothallic) species which did not form oospores when cultured individually. Both A^1 and A^2 isolates of *P. parasitica* were detected in this study. All tested A^1 isolates of *P. parasitica* obtained from diseased ornamental plants in Araceae belong to sexuality type S^1 (13,15) since they can be stimulated by A^2 isolate (p731) of *P. parasitica* and induce A^2 to form oospores (Table 1). Meanwhile, all A^2 isolates of *P. parasitica* can be stimulated by A^1 isolate (p991) of *P. parasitica* and induce A^1 to form oospores, thus belonging to sexuality

TABLE 2. Characteristics of spores of *Phytophthora* isolated from ornamental plants in the family of Araceae in Taiwan

Species & host	Mating type	Size of sporangia (μm)			Length of pedicel (μm)	Diameter (μm) of		Antheridium (μm)	
		Length	Width	L/W		Oogonia	Oospores	Length	Width
P. parasitica									
Aglaonema commutatum	A^1	35–50[1] (42.3)	25–40 (33.3)	1.15–1.35 (1.27)	—	20.6–32 (26.0)	15–25.5 (22.4)	7.5–15.5 (10.8)	10–17 (13.3)
Anthurium andreanum	A^2	41–62.5 (51.7)	30–47.5 (40.3)	1.09–1.64 (1.29)	—	19.8–33 (26.8)	17.5–28.5 (23.1)	7.5–14.5 (10.5)	10–11.9 (13.5)
Dieffenbachia maculata	A^2	41–80 (60.3)	29–55 (40.2)	1.11–1.88 (1.51)	—	19.8–29 (25.6)	16.5–24.8 (21.9)	7.8–14 (10.3)	12–18.8 (15.2)
Epipremum aureum	A^1	47.5–70 (55.6)	32.5–50 (42.8)	1.10–1.73 (1.30)	—	24.8–32 (28.6)	21–27.8 (24.5)	7–14.5 (10.9)	9.5–18 (14.1)
	A^2	32.5–53 (41.3)	25–40 (33.5)	1.15–1.35 (1.24)	—	25–35.5 (28.3)	19–32 (24.3)	6–17.8 (9.9)	6.5–17.8 (13.9)
Philodendron spp.	A^1	45–80 (64.7)	37.5–57 (49.5)	1.11–1.82 (1.31)	—	21–29.8 (25.8)	13–27 (22.1)	8.8–13.8 (10.6)	9.5–17 (13.0)
	A^2	25–47.5 (36.8)	20–40 (30)	1.15–1.35 (1.23)	—	24–32.5 (27.7)	19.5–28 (24.4)	9.5–16 (11.8)	12.8–19.5 (15.5)
P. meadii									
Aglaonema nitidium	A^2	55–120 (80.5)	29–85 (42.5)	1.6–2.2 (1.95)	5–20 (10.3)	23.8–30.3 (27.4)	21–29 (24.4)	10.5–15.5 (12.4)	12.3–18.5 (15.9)

1. The figures in parenthesis refer to average values.

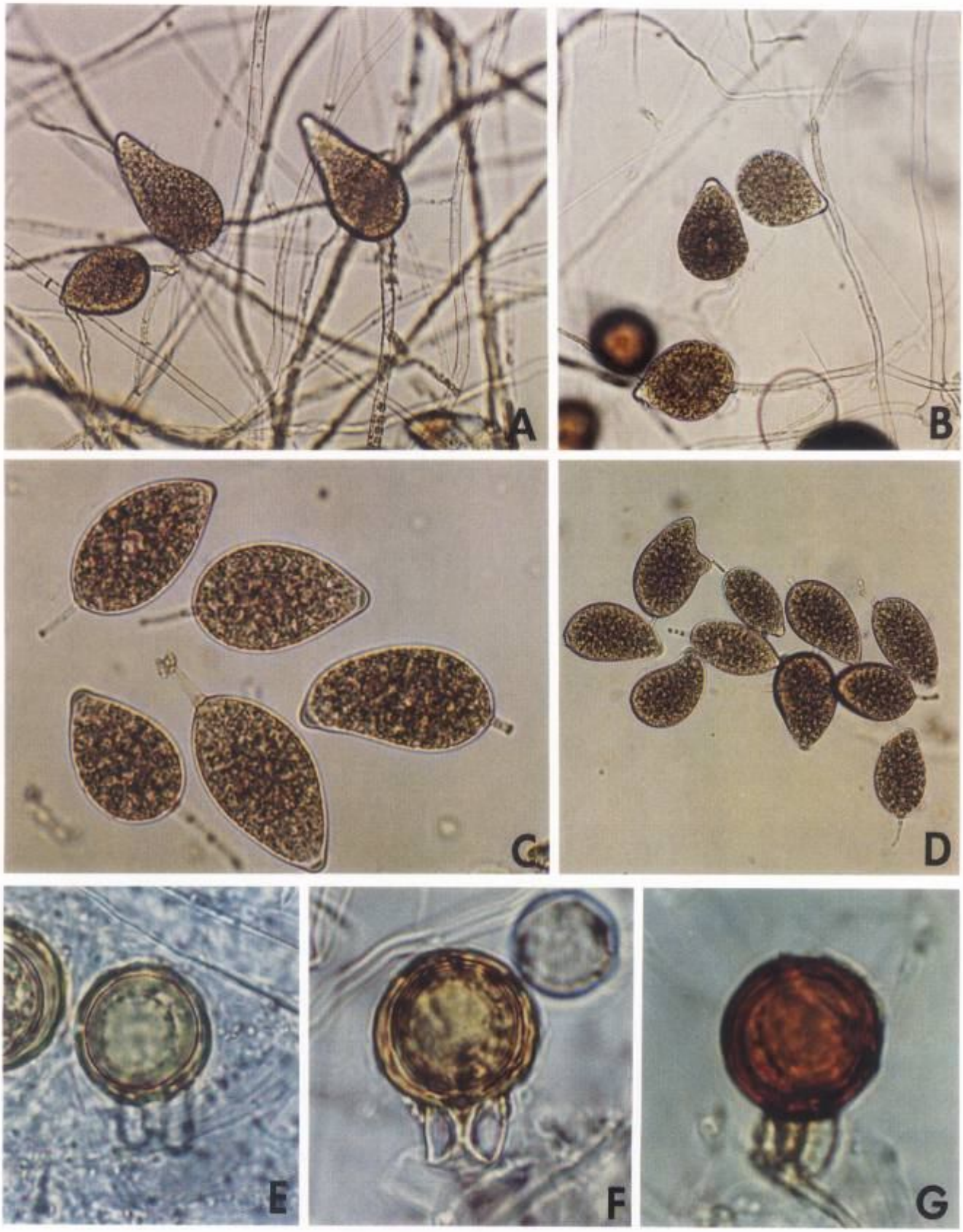

Fig. 2. Sporangia of *Phytophthora parasitica* from *Dieffenbachia maculata* (A, B), and of *Phytophthora meadii* from *Aglaonema nitidum* (C, D); Oospores of *P. parasitica* from *D. malculata* (E, F), and of *P. meadii* from *A. nitidum* (G). (A, B, D, × 240; C, × 480; E, F, G, × 960)

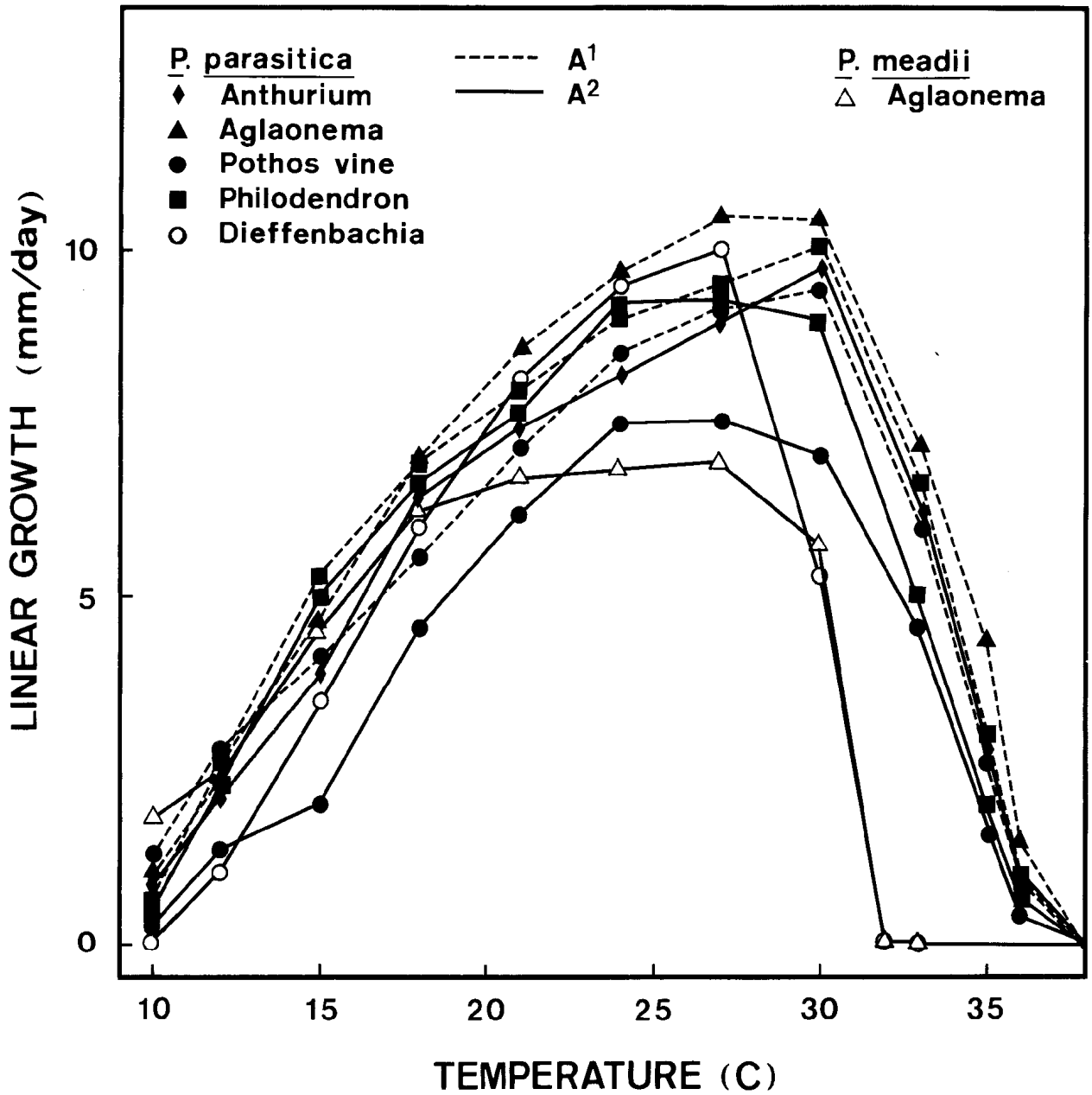

Fig. 3. Growth rate of isolates of *Phytophthora* spp. isolated from ornamental plants on 5% clarified V-8 agar.

type S^1. The morphological characteristics of sex organs produced by tested isolates of *P. parasitica* themselves through chemical stimulation was similar to each other among isolates from different hosts (Fig. 2E,F). The oogonia and oospores were near spherical, and with smooth walls. The average diameter of oogonia and oospores ranged from 25.6 to 28.6 μm and 21.9 to 24.5 μm, respectively (Table 2). Antheridia had an average measurement of 9.9–11.8 × 13.0–15.2 μm.

The A^2 isolates of *P. meadii* isolated from aglaonema can stimulate A^1 to produce oospores and vice versa, belonging to type S^4. However, the amount of oospores formed by *P. meadii* through chemical stimulation were only about 30–100/cm^2 while those produced by *P. parasitica* from Araceae were more than 1×10^5/cm^2 under the same conditions. The oospores formed by this fungus itself were spherical with thick walls, and the oogonial walls were smooth (Fig. 2G). The size of oogonia, oospores, and antheridia measured 23.8–30.3 μm (*av.* 27.4 μm), 21–29 μm (*av.* 24.4 μm) in diameter, and 10.5–15.5 × 12.3–18.5 μm (*av.* 12.4–15.9 μm), respectively.

All tested isolates of *Phytophthora* species were able to grow on 5% clarified V-8 juice agar at 12 to 32 C but not at 8 C nor 38 C (Fig. 3). Isolates of *P. parasitica* were able to grow on medium from 12 to 36 C except the isolates obtained from dieffenbachia, which grow from 10 to 32–33 C. The optimum temperature for growth of tested isolates was about 27–30 C for A^1 mating type of *P. parasitica* (9.5–10.5 mm/day), and about 24–30 C for A^2 mating type of *P. parasitica* (7.6–10.0 mm/day). The tested isolates of *P. parasitica* from dieffenbachia grew 9.8 mm/day at optimum temperature (27 C). The

temperatures for growth of *P. meadii* from aglaonema were 10 to 32 C, and optimum temperatures were about 21-27 C (6.9 mm/day).

Pathogenicity tests

Symptoms of diseases on artificially inoculated ornamental plants caused by their respective *Phytophthora* species were similar to those occurring under natural field conditions. Most tested isolates from diseased ornamental plants were highly pathogenic to their hosts (Table 3,4). Symptoms produced under natural field conditions also appeared on inoculated plants about 3-10 days after inoculation.

The isolates of *P. parasitica* from dieffenbachia caused leaf blight, wilt, and death to two varieties (Hawaii Snow (白玉) and Rudolph Roehrs (白葉)) of *D. maculata*, while it did not cause serious disease symptom on unwounded *Dieffenbachia amoena* Bull cv. "Tropic Snow" (夏雪) in pathogenicity tests. The same isolates did not cause foliage diseases on test plants of aglaonema, philodendron and pothos vine, but were mildly pathogenic to anthurium leaves when wounded. All tested isolates of *P. parasitica* from aglaonema, anthurium, philodendron, and pothos vine were able to infect each other host in cross-inoculation tests (Table 3).

Isolates of *P. meadii* obtained from *A. nitidum* were able to attack *A. commutatum* cv. "Silver queen" (銀后) and "Maria" (綠葉), *Philodendron scandens* subsp. *oxycardium* Koch & Sello (parlor ivy) (心葉蔓綠絨), and pothos vine in pathogenicity tests (Table 4). The fungus did not attack unwounded dieffenbachia, and most other philodendron in Araceae. The symptoms caused by *P. meadii* on *A. commutatum* and pothos vine were similar to those caused by *P. parasitica*. Without wound *P. meadii* caused tip and marginal blight on leaves of *A. commutatum*, while it caused black spots (1-5 cm diam.) on leaves, and stem (vine) rot of *P. scandens* and *E. aureum*.

DISCUSSION

Prior to our report only three species of *Phytophthora* have been reported to be pathogenic to ornamental plants in the family of Araceae. Most of them, including philodendron and spathiphyllum (白鶴芋), were infected with *P. parasitica* (also reported as *P. nicotianae*, or *P. nicotianae* var. *parasitica*) (7,19). Other Phytophthora diseases are diseases of dieffenbachia caused by *P. mexicana* Hotson & Hartge (18) or *P. palmivora* (Butler) Butler (11,21). However, disease of dieffenbachia caused by *P. palmivora* has not been found during the course of this study. All Phytophthora diseases of ornamental plants in Araceae were first reported in Taiwan. All of them, including aglaonema, anthurium, dieffenbachia, philodendron, and pothos vine were found to be the hosts of *P. parasitica*. In addition, aglaonema was also infected with *P. meadii*. *P. parasitica* and *P. meadii* appear not to have been previously described as pathogens of aglaonema, as well as *P. parasitica* as pathogen of anthurium and pothos vine.

Based on the survey data, more than 80% of Phytophthora diseases of ornamental plants in the family of Araceae in Taiwan were caused by *P. parasitica* (Table 1). According to previous reports, *P. parasitica* was one of the most common species of *Phytophthora* attacking fruits, vegetables and flowers and most widely distributed in Taiwan (1,4,6,8). Meanwhile, most tested isolates of *P. parasitica* from Araceae were also pathogenic to the host plants within the family in cross inoculation tests except for the isolates from dieffenbachia (Table 3). This diverse source of inoculum may explain the seriousness of Phytophthora foliage diseases of ornamental plants in Taiwan. Although Phytophthora disease of *Spathiphyllum* sp. was not found in this study, many isolates of *P. parasitica* from Araceae were able to infect this plant causing leaf tip blight with black discoloration similar to the description reported in the U.S.A. (7).

Only a single species of *Phytophthora* was isolated from individual diseased plant. However, both A^1 and A^2 mating types of *P. parasitica* were simultaneously detected in the same plants of philodendron and pothos vine, indicating the possibility of sexual reproduction by this fungus in nature.

Phytophthora disease of *D. maculata* caused by *P. mexicana* has been reported in Germany in 1983 by Krober *et al* (18). The disease symptoms on infected plants, as well as morphological and physiological characteristics of the fungus described by the authors were very similar to those isolates obtained from *D. maculata* in Taiwan during this study. Both isolates from dieffenbachia in Germany and Taiwan produced spherical hyphal swellings on agar medium. Both of them formed sporangia with a longer L/W ratios of 1.6 for the German isolates and 1.51 for the Taiwanese isolates, while typical isolates of *P. parasitica* were about 1.2-1.3 (Table 2). Meanwhile, the maximum growth temperatures for both isolates from dieffenbachia were 32-33 C, while typical isolates of *P. parasitica* were usually about 36-37 C (Fig. 3). Moreover, the fungus were distinct from other Araceae isolates of *P. parasitica* in their ability to incite disease on *D. maculata* but not to other tested plants in Araceae under unwounded conditions (Table 3). The dieffenbachia isolates from Taiwan were sent to Dr. Ho in New York State University for identification. Based on the morphological characteristics, such as sporangium shape, chlamydospores, and colony patterns, he considered them as atypical *P. parasitica* since they were closer to *P. parasitica* rather than the original isolates of *P. mexicana* from tomato (9). All tested isolates of *P. parasitica* from other plants in Araceae had essentially all the characteristics of typical *P. parasitica* (Table 2; Fig. 3) (20,22,23,24).

The isolates of *P. parasitica* from dieffenbachia and *P.*

TABLE 3. Cross-inoculation tests of *Phytophthora parasitica* on leaves of ornamental plants in Araceae

Source of inoculum from	Mating type	Plants inoculated							
		Aglaonema commutatum (銀后、綠葉)	*Aglaonema nitidum* (亮葉)	*Anthurium andreanum*	*Dieffenbachia maculata* (白玉、白葉)	*D. amoena* (夏雪)	*Epipremnum aureum*	*Philodendron* spp. (紅公主、帝王、立葉、粉彩)	*P. scandens* subsp. *oxycardium* (心葉)
A. commutatum	A^1	++[1]	−(−)[2]	− (+)	− (−)	−(−)	+++	+	+++
A. andreanum	A^2	++	−(−)	+++	− (−)	−(−)	+++	+(++)	+++
D. maculata	A^2	− (−)	−(−)	− (±)	+++	+(++)	− (−)	−(−)	− (−)
E. aureum	A^1	++	−(−)	+	− (−)	−(−)	+++	+(++)	+++
	A^2	+	−(−)	+++	− (+)	−(−)	+++	+(++)	+++
Philodendron sp.	A^1	++	−(−)	++	− (−)	−(−)	+++	+(++)	+++
	A^2	+	−(−)	++	− (−)	−(−)	+++	+(++)	+++

1. +++: Highly pathogenic; ++: Moderately pathogenic; +: Weakly pathogenic; −: Non-pathogenic.
2. The first figures refer to disease incidence under unwounded condition; the second, in parenthesis refer to wounded condition.

TABLE 4. Pathogenicity of *Phytophthora meadii* isolated from *Aglaonema* sp.

Tested plant	Disease incidence		Disease symptoms
	Unwounded	Wounded	
Aglaonema commutatum (銀后、綠葉)	+++[1]	N.T.[2]	Leaf marginal blight or water soaking spots
Aglaonema nitidum	+++	N.T.	Big black spots on leaves
Anthurium andreanum	+	++	Light brown spots on leaves
Dieffenbachia maculata (白玉、白葉) & *D. amoena* (夏雪)	−	−	
Epipremnum aureum	+++	N.T.	Black or brown spots on leaves; petiole, stems, and root rot
Philodendron scandens subsp. *oxycardium* (心葉)	+++	N.T.	Greenish spots on leaves; stem and root rot
Philodendron spp. (紅公主、立葉、粉彩)	−	±	Water soaking spots on leaves
Spathiphyllum sp. (白鶴芋)	+	++	Leaf tip blight with black discoloration
Syngonium podophyllum (果芋)	−	−	

1. +++: Highly pathogenic, ++: Moderately pathogenic, +: Weakly pathogenic, −: Non-pathogenic.
2. N.T. = Not tested.

meadii from aglaonema were first discovered in Taiwan. The diseased plants infected with the two pathogens detected in this survey were introduced to Taiwan from Europe. Therefore, both pathogens may have been introduced together with imported diseased plants or culture media from other countries.

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LITERATURE CITED

1. Ann, P. J. 1984. Species, mating types and pathogenicity of *Phytophthora* distributed in citrus orchards in Taiwan. Trans. Br. Mycol. Soc. 82:631-634.
2. Ann, P. J., and Ko, W. H. 1988. Hormonal heterothallism in *Phytophthora parasitica*: a novel mode of sexual reproduction? J. Gen. Microbiol. 134:2985-2992.
3. Ann, P. J., and Ko, W. H. 1990. New Phytophthora diseases of flowers and ornamental plants in Taiwan. plant Prot. Bull. 32:341. (In Chinese, Abstract)
4. Ann, P. J., Ko, W. H., and Kao, C. W. 1991. Disease controls of soil-borne *Phytophthora* and their suppressive soils in Taiwan. Plant Prot. Bull. 33:142-147. (In Chinese)
5. Boesewinkel, H. J. 1976. Storage of fungal cultures in water. Trans. Br. Mycol. Soc. 66:183-185.
6. Chang, H. S. 1983. Crop diseases incited by *Phytophthora* fungi in Taiwan. Plant Prot. Bull. 25:231-237.
7. Chase, A. R. 1987. Compendium of Ornamental Foliage Plant Diseases. APS press, St. Paul, Minnesota, 92 pp.
8. Ho, H. H. 1990. Taiwan *Phytophthora*. Bot. Bull. Academia sinica 31:89-106.
9. Hotson, J. W., and Hartge, L. 1923. A disease of tomato caused by *Phytophthora mexicana*, sp. nov. Phytopathology 13:519-530.
10. Hwang, S. C., Ko, W. H., and Aragaki, M. 1976. A simplified method for sporangial production by *Phytophthora cinnamomi*. Mycologia 68:1233-1234.
11. Knauss, J. F. 1974. Pyroxychlor, a new and apparently systemic fungicide for control of *Phytophthora palmivora*. Plant Dis. Reptr. 58:1100-1104.
12. Ko, W. H. 1978. Heterothallic *Phytophthora*: evidence for hormonal regulation of sexual reproduction. J. Gen. Microbiol. 107:15-18.
13. Ko, W. H. 1980. Hormonal regulation of sexual reproduction in *Phytophthora*. J. Gen. Microbiol. 116:459-461.
14. Ko, W. H. 1981. Reversible change of mating type in *Phytophthora parasitica*. J. Gen. Microbiol. 125:451-454.
15. Ko, W. H. 1988. Hormonal heterothallism and homothallism in *Phytophthora*. Ann. Rev. Phytopathol. 26:57-73.
16. Ko, W. H., Chase, L., and Kunimoto, R. 1973. A

microsyringe method for determining concentration of fungal propagules. Phytopathology 63:1206-1207.
17. Ko, W. H., Chang, H. S., and Su, H. J. 1976. Isolates of *Phytophthora cinnamomi* from Taiwan as evidence for an Asian origin of the species. Trans. Br. Mycol. Soc. 72: 353-358.
18. Krober, H., Kiewnick, L., and Richter, J. 1983. Phytophthora-stammbasisfaule an *dieffenbachia maculata*. (Stem base rot of *Dieffenbachia maculata* caused by *Phytophthora mexicana*). Phytopath. Z. 107:244-249. (In Germany)
19. Ridings, W. H., and Mcritchie, J. J. 1974. Phytophthora leaf spot of *Philodendron oxycardium* and related species. Proc. Fla. State Hortic. Soc. 87:442-447.
20. Stamp, D. J., Waterhouse, G. M., Newhook, F. J., and Hall, G. S. 1990. Revised Tabular Key to the species of *Phytophthora*. Mycol. Pap. 162, Comm. Mycol. Ins. Kew, Surrey, England.
21. Tompkins, C. M., and Tucker, C. M. 1947. Stem rot of *Dieffenbachia picta* caused by *Phytophthora palmivora* and its control. Phytopathology 37:868-874.
22. Tucker, C. M. 1931. Taxonomy of the genus *Phytophthora* de Bary. Mo. Agric. Exp. Sta. Res. Bull. 153. 208 p.
23. Waterhouse, G. M. 1963. Key to the species of *Phytophthora* De Bary. Mycol. Pap. 92. Comm. Mycol. Ins. Kew, Surrey, England.
24. Waterhouse, G. M. 1970. The genus *Phytophthora* De Bary- diagnoses (or descriptions) and figures from the original papers. Mycol. Pap. 122. Comm. Mycol. Ins. Kew, Surrey, England.

摘　　要

安寶貞．1992．台灣天南星科觀賞植物之疫病．植病會刊 1:79-89．(嘉義市　嘉義農業試驗分所)

自 1988–1991 年調查本省天南星科觀賞作物上之疫病菌，發現 *Phytophthora parasitica* 危害火鶴花、蔓綠絨 (帝王、紅公主、粉彩、Tuxla、……)、粗肋草 (銀后)、及萬年青 (黛粉葉) (白玉、白葉)；*Phytophthora meadii* 危害粗肋草 (亮葉) (*Aglaonema nitidium*)。病原菌主要感染植物之葉部，造成葉片腐敗；但亦可侵染莖部、氣生根、與地下根系，嚴重時引起植株死亡。病原性測定，被接種的植株均出現與田間一致的病徵，相同的病原菌亦可自罹病組織上再分離得到。除自萬年青分得之 *P. parasitica* 菌株外，自其他天南星科寄主得到之 *P. parasitica* 菌株，均可互相感染彼此之寄主。所有自粗肋草上分離得到之 *P. parasitica* 均爲 A^1 菌株；所有自火鶴花與萬年青上分得之 *P. parasitica* 均爲 A^2 菌株；而 A^1 與 A^2 菌株同時自黃金葛與蔓綠絨之病組織上分到。分得之 *P. meadii* 均爲 A^2 配對型。天南星科觀賞植物之疫病在台灣均爲新紀錄；*P. parasitica* 危害火鶴花、粗肋草、及黃金葛，及 *P. meadii* 危害粗肋草，在世界其他地區亦尚未被報導過。

關鍵詞：疫病、天南星科、觀賞植物、火鶴花、粗肋草、萬年青 (黛粉葉)、黃金葛、蔓綠絨、*Phytophthora parasitica*、*P. meadii*。