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New Diseases and Records of Flowering Potted Plants Caused by *Phytophthora* species in Taiwan

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ABSTRACT

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Phytophthora diseases of flowering potted plants were investigated from 1989 to 1999. A total of 16 new diseases, which have not been formally reported in Taiwan, were found and described in the study. An atypical type of *Phytophthora capsici* was found to cause wilt and death of azalea. *P. citrophthora* attacked the whole plants of anthurium and periwinkle, and the basal stem and root tissues of cyclamen. *P. parasitica* was detected from the infected diseased tissues of seven species of plants including *Aphelandra* sp. (whole plant wilt), bougainvillea (leaf and flower blight), hibiscus (root rot), flame vine (leaf and flower blight), desert rose (young tissue and stem blight), chincherinchees (wilt and blight of whole plants), and *Aeschynanthus* sp. (wilt). While *P. palmivora* caused flower blight of curcuma and wilt of garden petunia. Besides, *P. cinnamomi* was isolated from the rotted basal stem tissues of begonia , *P. citricola* from the blighted leaves of Taiwan pleione, and *P. cryptogea* from the diseased root tissues of sweet alyssum. Disease symptoms similar to those occurring in natural conditions were reproduced when each host was inoculated with zoospore suspension of their respective isolates of *Phytophthora* species in pathogenicity tests. Same species of *Phytophthora* was reisolated from all artificially infected tissues. Among these new diseases, *P. capsici* on azalea, *P. cinnamomi* on begonia, *P. citricola* on Taiwan pleione, *P. citrophthora* on anthurium, *P. cryptogea* on sweet alyssum, *P. parasitica* on *Aeschynanthus* sp., chincherinchees, flame vine and desert rose, and *P. palmivora* on curcuma have not been described in any other places previously.

Key words : New disease records, *Phytophthora capsici, P. cinnamomi, P. citrophthora, P. citricola, P. cryptogea, P. parasitica, P. palmivora*, Flowering potted plants, Taiwan

INTRODUCTION

Ornamental plants have become important economic commodities in Taiwan recently. Many famous varieties were introduced from foreign countries and grown in the entire island. New diseases of these plants occurred subsequently and caused substantial losses. The associated pathogens may invade into the island coming along with the imported plants. Meanwhile, some pathogens may be endemic but become devastating due to high susceptibility of the introduced plants. Besides, frequent heavy rainfall and the moist environmental conditions in Taiwan are favorable to the spread of sporangia and zoospores of *Phytophthora* species in the fields [12,15,19]. For this reason, survey of new diseases of flower plants associated with *Phytophthora* species was conducted continuously. New *Phytophthora* diseases of carnation [10], baby's breath [11], lily [13], white arum lily [29], orchids [5], English ivy [4], ornamental plants in Araceae [3] and Compositae [6], and some potted flowers [2] have been published recently. I reported herein new recorded *Phytophthora* diseases of other important flowering potted plants which were investigated from 1989 through 1999 and all new diseases were proven *via* Koch's postulate procedures. All the 16 *Phytophthora* diseases were formally reported for the first time in Taiwan.

MATERIALS AND METHODS

Isolation, maintenance and identification

Diseased tissues of affected plants were collected from fields. Pieces of tissues taken from stems or roots (ca. 5-10 mm long), leaves or flowers (ca. 7 X 7 mm^2) with advanced

disease symptoms were disinfested with 0.5% NaClO for 3 min. The treated tissues were plated onto selective medium. The selective medium consisting of 5% clarified V-8 juice agar (5% V-8 juice plus 0.2% $CaCO_3$ centrifuged at 1,500 rpm for 5 min and 2% Bacto agar) was supplemented with 200 ppm Ampicillin, 50 ppm mycostatin, and 10 ppm pentachloro-nitrobenzene [26]. After incubation at 24 ℃ for 1-7 days, mycelial mats of *Phytophthora* species growing out of diseased tissues on selective medium were transferred to 5% V-8 juice agar. Single-zoospore cultures were obtained using the method described by Ko [24]. Cultures were maintained on 5% V-8 juice agar blocks in sterile water in test tubes at 24 ℃ [14]. Classification Keys described by Stamps *et al*. [31] and Waterhouse [34,35] were used for identification of the *Phytophthora* isolates obtained.

Production of sporangia and zoospores

The method described by Hwang *et al* [21] was used to produce large amount of sporangia for morphological studies and pathogenicity tests. Zoospore suspension was prepared by chilling the mycelial mats with sporangia at 15 ℃ for 30 min for most of species of *Phytophthora*. Whereas, mycelial mats of *P. cryptogea* were chilled for about 4 hr for differentiation of sporangial cytoplasm (unpublished data).

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 ℃ in darkness for 10 days. Isolates, which did not form oospores singly, were paired with the standard A^1 (p991) and A^2 (p731) mating type of *Phytophthora parasitica* singly for determination of their mating types [8]. Those isolates forming oospores in single cultures were designated as homothallic. Those forming oospores when paired with the A^2 tester were A^1 type; while those forming oospores with A^1 tester were A^2 type. For those without oospores when paired with any testers were designated as neuter (A^o type).

Production of oospores

The polycarbonate membrane method described by Ko [22] was used for study of sexual reproduction of heterothallic species of *Phytophthora*, and for determination of their sexuality types [23].

Growth of *Phytophthora*

Phytophthora isolates were grown on 5% V-8 juice agar for 3-5 days. Agar discs (5 mm diam.) cut from the periphery of the colonies with a sterile cork borer were each placed on the edge of a V-8 agar plate and incubated at 8, 10, 12, 15, 18, 21, 24, 27, 30, 33, 36 or 38 ℃ in darkness. Colonies were measured daily until the mycelia reached the opposite edge of the plates or 10 days after inoculation. The lowest and highest temperatures of the tested conditions, which could support the mycelial to grow, were designated as minimum and maximum growth temperatures, respectively. While the temperature ranges supporting mycelial growth at the fast conditions were as optimum growth temperatures. Four plates were used for each temperature and the experiment was repeated twice.

Pathogenicity tests

One or two isolates of *Phytophthora* obtained from each host species were selected for pathogenicity tests. Zoospore suspension used as inoculum was counted and adjusted to 10^5-10^6 zoospores/ml with aid by a microliter pipette [25]. Seedlings or cuttings used as inoculated plants were grown in disinfested soils in pots. For root inoculation, roots of tested plants were moved from soil particles, dipped in zoospore suspension at 24 ℃ for 24 hr, and replanted in potted soil. For flower, leaf, stem, or basal stem inoculation, a small piece of sterile cotton containing 1 ml of zoospore suspension was placed on/around the portions of tested plants. Five plants were inoculated for each treatment and tests were repeated twice. Controls for each test were similarly treated with distilled water. After incubation at 24 ℃ for 3 days, disease incidence was rated every 3 days. Diseased tissues were taken from artificially infected plants for pathogen reisolation following the procedures as described above.

RESULTS

Investigation of Phytophthora diseases of flowering potted plants as first formal report in Taiwan.

A total of 16 new *Phytophthora* diseases of flowering potted crops were found in the study. Some of these diseases have been informally mentioned in the abstracts of annual year reports and listed in *Phytophthora* book [20]. But All the diseases have not been described in detail as well as none of them have been proved via Koch's postulate study before. Most Phytophthora diseases of these crops were found in the wet seasons when they were floriculturally grown in greenhouse or directly planted in the fields. Some of them became very serious under moist conditions during continuous rainfall and caused considerately economic losses.

The names of affected flower plants, disease symptoms, numbers of isolates obtained and locations associated with each *Phytophthora* disease were listed on Table 1 and some of pictures of disease symptoms were showed on Figures. Phytophthora diseases and the characteristics of the respective causal agents were described as follows:

Diseases caused by *P. capsici* Leonian (on azalea, 西洋杜鵑)

Serious *Phytophthora* wilt was found on some import potted azalea plants in the flower shops at Tianwei, Changhua. A fungus was detected from every affected portion

of the plants including flower, leaf, stem and root systems. The affected tissues showed water-soaked discoloration initially and turned dark brown or black later. Eventually, the infected plants drooped and died. A total of four A^o isolates (sexuality type 16 [23]) of *P. capsici* were isolated. The azalea isolates were not pathogenic to pepper. They produced chlamydospores and deciduous sporangia with pedicels 12.5-(51.7)-125 μm long. The maximum temperatures for mycelial growth were 32-33 ℃. The azalea isolates were identified as an atypical *P. capsici* [27]. The characteristics of sporangia and growth temperatures of a tested isolate were listed on Table 2. Azalea is very susceptible to the pathogen. When zoospore suspension (about 10^6 spores/ml) was sprayed, the inoculated unwounded-potted plants showed symptoms within 2 days. All of the inoculated cuttings were killed within two weeks. Whereas, all plants inoculated with distilled water remained healthy during the test periods. *P. capsici* identical to the isolates used for inoculation was reisolated from the affected tissues.

Diseases caused by *P. cinnamomi* (on begonia, 四季秋海棠)

Four 4 A^1 isolates (sexuality type S1 or S2 [23]) of *Phytophthora cinnamomi* were isolated from the basal stem and root tissues of infected begonia in Chiayi. The affected portions showed water-soaked discoloration initially and turned dark brown or black later (Fig. 1). All infected plants died eventually. All the isolates of *P. cinnamomi* obtained from begonia produced non-papillate and non-deciduous sporangia, and formed coralloid hyphal swellings in clusters. However, chlamydospores were absent. All isolates could grow at 36 ℃. The begonia isolates were identified as an atypical type of *P. cinnamomi* [35]. The characteristics of these isolates were listed on Table 2. Begonia was not very susceptible to the pathogens. When 1 ml of zoospore

Table 1. First isolation of *Phytophthora* species from diseased tissues of flowering potted crops as new records in Taiwan.

Name of host Scientific, English & Chinese	Infected Sites	*Phytophthora* species	First isolation Year	Location and No. of isolates & mating type obtained	Disease severity in the fields
Rhododendron simsii (azalea) 西洋杜鵑	Whole plant	*P. capsici* (atypical)	1994	Changhua (4 A^o)	+++[1]
BegoniaX semperflorens-cultorum (begonia) 四季秋海棠	Basal stem & root	*P. cinnamomi* (atypical)	1996	Chiayi (4 A^1)	+
Pleione formosana (Taiwan pleione) 一葉蘭	Whole plant	*P. citricola*	1998	Taichung (3 A^o)	+++
Catharanthus roseus (periwinkle)日日春	Whole plant	*P. citrophthora*	1997	Taipei (4 A^1)	+++
Anthurium spp. (anthurium) 火鶴花	Leaf, stem, & root	*P. citrophthora*	1992	Nantow (21 A^1), Chiayi (8A^1)	++
Cyclamen persicum (cyclamen) 仙克來	Basal stem, bulb & root	*P. citrophthora*	1992	Changhua (2 A^1)	+
Lobularia maritima (sweet alyssum) 香雪球	Basal stem	*P. cryptogea*	1990	Taichung (1 A^1)	++
Aeschynanthus sp.口紅花	Whole plant	*P. parasitica*	1993	Changhua (4 A^1, 6A^2)	++
Ornithogalum ixias (chincherinchees) 天鵝絨	Whole plant	*P. parasitica*	1999	Taichung (4 A^2)	+++
Bougainvillea spp. (bougainvillea) 九重葛	Flower & Leaf	*P. parasitica*	1996	Taichung (5 A^2), Taipei (2 A^1)	++
Pyrostegia venusta (flame vine) 炮仗花	Flower	*P. parasitica*	1990	Chiayi (4 A^2)	++
Adenium obesum (desert rose) 沙漠玫瑰	Leaf & stem	*P. parasitica*	1998	Taichung (2 A^1)	+++
Aphelandra sp. (zebra plant) 單葯花	Whole plants	*P. parasitica*	1996	Changhua (5 A^2)	++
Hibiscus rosa-sinensis (Hawaiian hibiscus) 朱槿	Root	*P. parasitica*	1994	Chiayi (9 A^1)	++
Curcuma alsimalifolia (curcuma) 薑荷花	Flower	*P. palmivora*	1994	Taichung (1 A^1)	++
Petunia hybrida (garden petunia) 矮牽牛	Whole plant	*P. palmivora*	1989	Chiayi (4 A^2)	++

[1.] Degree of disease severity in the field: +++, serious; ++: moderate; +: slight.

Table 2. Size of sporangia and growth temperatures of isolates of *Phytophthora* spp. obtained from the flowering potted plants in this study

Host	*Phytophthora* species	Sporangia		Pedicel (μm)	Growth reaction to temperatures (℃)[3]
		Length X width (μm)	Length/width		
Rhododendron 西洋杜鵑	*P. capsici* (atypical)	32-(47.8)-60 X 20-(27.2)-35 [1]	1.29-(1.76)-2.2 [1]	12.5-(64.6)-125	<10-(24-28)-33
Begonia 四季秋海棠	*P. cinnamomi* (atypical)	30-(49.8)-72.5 X 22.5-(33.9)-44	1.18-(1.47)-1.83	-[2]	<10-(28-32)-36
Taiwan pleione 一葉蘭	*P. citricola*	45-(52.4)-61 X 32.5-(35.9)-45	1.18-(1.46)-1.84	-	<10-(24)-32
Periwinkle 日日春	*P. citrophthora*	42-(52.7)-60.4 X 28-(35.9)-40	1.22-(1.47)-1.74	7.5-(13.7)-30	<10-(24-28)-33
Anthurium 火鶴花	*P. citrophthora*	45-(57.9)-70 X 27.5-(38.0)-52.5	1.22-(1.54)-2.0	7.5-(15.2)-38	<10-(24-28)-33
Cyclamen 仙克來	*P. citrophthora*	40-(54.5)-67.5 X 25-(32.7)-42.5	1.13-(1.69)-2.3	6.5-(16.3)-35	<10-(24-28)-33
Sweet alyssum 香雪球	*P. cryptogea*	40-(50.4)-65 X 27.0-(33.3)-40	1.11-(1.51)-1.85	-	<10-(24-28)-33
Aeschynanthus sp.口紅花	*P. parasitica*	46-(48.2)-80 X 30-(37.1)-44	1.04-(1.30)-1.6	-	10-(24-32)-36
Chincherinchees 天鵝絨	*P. parasitica*	31-(50.2)-60 X 25-(40.0)-50	1.11-(1.26)-1.54	-	10-(28-32)-36
Bougainvillea 九重葛	*P. parasitica*	46-(53.42)-67.2 X 30-(42.9)-50	1.09-(1.25)-1.44	-	10-(28-32)-36
Flame vine 炮仗花	*P. parasitica*	45-(52.1)-65 X 32-(41.3)-48	1.05-(1.26)-1.68	-	10-(24-32)-36
Desert rose 沙漠玫瑰	*P. parasitica*	34.5-(49.18)-62.5 X 25-(40.1)-50	1.09-(1.23)-1.71	-	10-(28-32)-36
Aphelandra sp.單葯花	*P. parasitica*	45-(56)-70 X 32.5-(40.6)-50	1.1-(1.38)-1.85	-	10-(24-32)-36
Hawaiian hibiscus 夏威夷朱槿	*P. parasitica*	47.5-(57.4)-70 X 35-(40.1)-50	1.20-(1.39)-1.75	-	10-(28-32)-36
Curcuma 薑荷花	*P. palmivora*	29-(36.0)-42.5 X 19.5-(21.5)-25	1.3-(1.65)-2.0	1.0-(1.8)-3.2	10-(24-28)-35
Garden petunia 矮牽牛	*P. palmivora*	35-(46.0)-57.5 X 21.0-(31.0)-39.5	1.18-(1.49)-2.02	1.0-(1.9)-3.5	10-(24-28)-35

1. Data in parenthesis are in average.
2. -: sporangia are non-deciduous.
3. Mycelial growth reactions to temperatures on V-8 agar are indicated as minimum -(optimum)-maximum.

suspension containing about 10^6 zoospores was inoculated on the basal stem of one-month-old seedlings without wound treatment, only about 20% tested seedlings showed symptoms and wilt after 14 days. *P. cinnamomi* identical to the cultures used for inoculation was reisolated from all the affected tissues.

Diseases caused by *P. citricola* Sawada (on Taiwan pleione 一葉蘭)

Serious Phytophthora blight was found on Taiwan pleione in an orchid field at Meifeng, Taichung. Three isolates of *P. citricola* were obtained. The fungus attacked whole plants of Taiwan pleione. The infected parts turned dark brown or black (Fig. 2), and all plants died under moist conditions eventually. The characteristics of pleione isolates are identical to the describes of *P. citricola* by Sawada [30]. All pleione isolates produced non-deciduous sporangia with semi-papilla in water. They were homothallic and formed abundant oospores with a paragynous (dominant) or amphigynous (rare) antheridium attached to each of them. The size of oogonia, oospores and antheridia ranged 25-(29)-32.5 μm, 22-(24.9)-27.5 μm, and 6-(11.0)-15 X 7.5-(13)-15 μm, respectively. The characteristics of sporangia and growth reaction to temperatures of tested isolates were listed on Table 3. Taiwan pleione is very susceptible to the fungus. When zoospore suspension (about 10^6 spores/ml) was sprayed, all the inoculated plants showed black rot symptoms and were killed within 7 days. *P. citricola* was reisolated from the affected tissues.

Diseases caused by *P. citrophthora* Leonian (on periwinkle 日日春, anthurium 火鶴花 and cyclamen 仙克來)

Phytophthora citrophthora was isolated from diseased periwinkle, anthurium, and cyclamen in the study. Four A^1 isolates (sexuality type S2 [23]) were obtained from the diseased tissues of periwinkle in Taipei. The fungus induced serious blight and wilt of the whole plants in the fields during wet seasons (Fig. 3). Results showed that the flowering plants were highly susceptible to the pathogen. All the inoculated plants died within one week when zoospore suspension of *P. citrophthora* containing 10^6 zoospores/ml was sprayed to 1-month-old potted seedlings without wounded treatment. The isolates produced finely radiate mycelial patterns on 5% V-8 agar plates. Meanwhile, sporangia of the isolates were with semi-spherical papilla and were partially deciduous with pedicels about 5-20 μm long. Chlamydospores were not found. The main characteristics of a tested isolate were listed on Table 2.

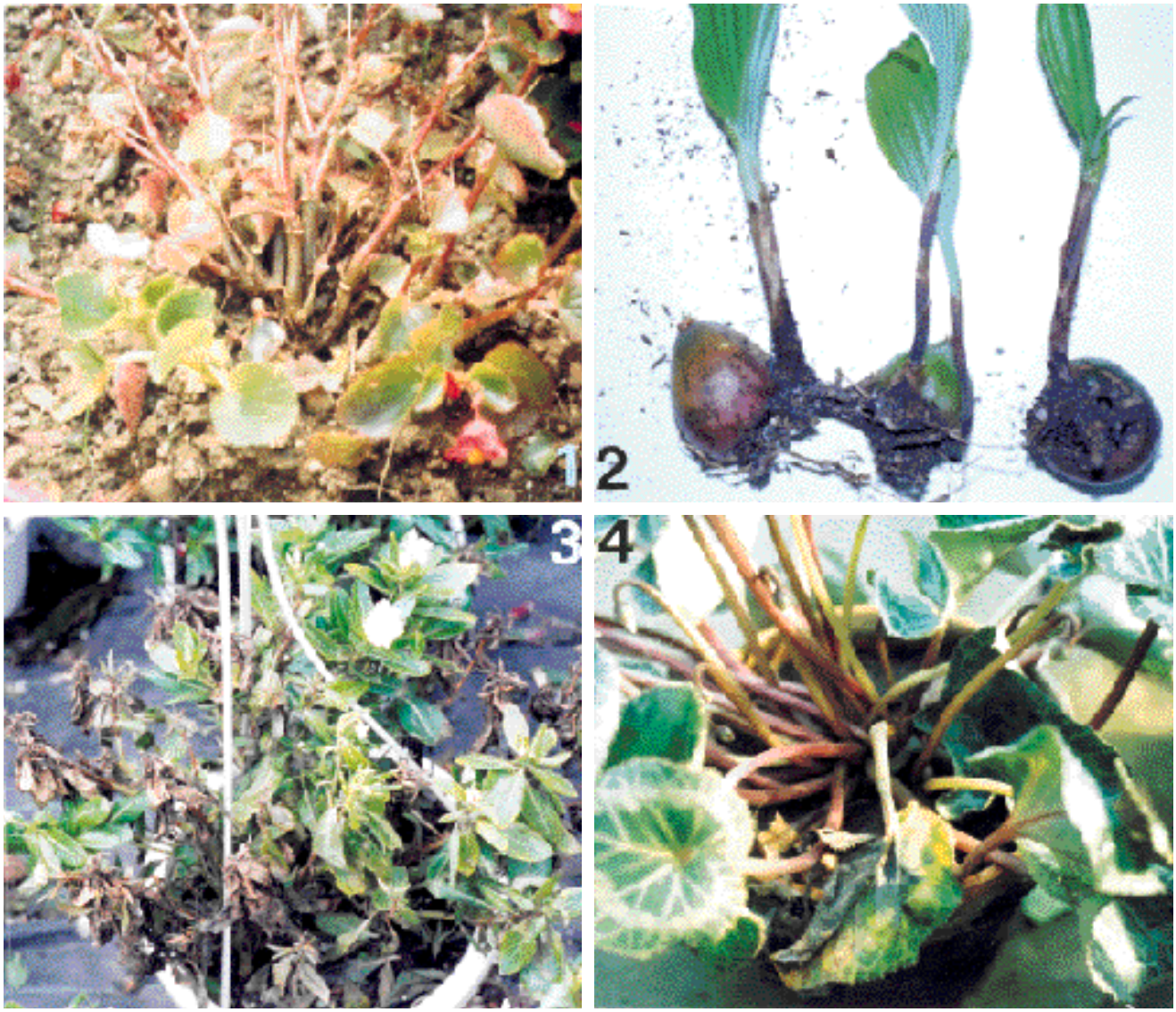
A total of 29 A^1 isolates of *P. citrophthora* were obtained from 5 anthurium gardens locating in Nantow and Chiayi. The pathogen caused leaf blight, stem and root rot of the affected plants. The characteristics of tested isolates from anthurium were listed on Table 2. *P. citrophthora* was

reisolated from the affected tissues of inoculated plants.

Two A^1 isolates of *P. citrophthora* were isolated from the diseased basal stem tissues (Fig. 4) of the potted cyclamen plants in a flower garden in Tianwei, Changhua. Pathogenicity of the cyclamen isolates was proved *via* inoculation study. Plants of the crop were susceptible to the fungus and showed symptoms similar to those appearing in the fields. All isolates of *P. citrophthora* obtained in this study belonged to the sexuality type S2 based on Ko's Hypothesis [23].

Diseases caused by *P. cryptogea* Pethybridge & lafferty (on sweet alyssum 香雪球)

Phytophthora wilt of sweet alyssum was found in a field at Holi, Taichung in 1990, and one A^1 isolate (sexuality type S2 [23]) of *P. cryptogea* was obtained from the diseased basal stem tissues of the crop. Sweet alyssum was very susceptible to the fungus and all inoculated 1-month-old seedlings were killed within 1 week after inoculation with 0.5 ml of zoospore suspension (about 10^6 zoospores/ml) on basal stems. The isolates produced abundant spherical, oval to angular hyphal swellings in network in water, which is a major criterion for identification of *P. cryptogea*. Sporangia formed on 5%V-8 agar plates and in water were non-papillate and non-deciduous. The characteristics of the tested isolate were listed on Table 2.



圖一至圖四：四種盆花疫病之病徵。 *Phytophthora cinnamomi* 引起四季海棠莖基部腐敗與倒伏 (圖一)； *P. citricola* 引起一葉蘭偽莖與葉片枯萎 (圖二)； *P. citrophthora* 引起日日春枯萎 (圖三) 與仙客來基腐、倒伏與葉枯 (圖四)。

Figs. 1 to 4. Diseases symptoms of four flowering potted crops caused by *Phytophthora* species. *Phytophthora cinnamomi* attacked the basal stem of a begonia plant (Fig. 1); *P. citrophthora* caused serious blight of a periwinkle (Fig. 2) & basal stem rot and leaf blight of a cyclamen plant (Fig. 3). *P. citricola* affected the pseudo stems and leaves of Taiwan pleione (Fig. 4).

Diseases caused by *P. parasitica* Dastur (= *P. nicotianae*) (on *Aeschynanthus* sp. 口紅花, chincherinchees 天鵝絨, bougainvillea 九重葛, flame vine 炮仗花, desert rose 沙漠玫瑰, *Aphelandra* sp. 單葯花, and Hawaiian hibiscus 夏威夷朱槿)

Phytophthora parasitica Dastur (= *P. nicotianae* Breda de Haan) probably is the most important and common pathogen in the genus *Phytophthora* to cause diseases of ornamental crops in Taiwan, today. In this survey, a total of seven diseases have not been formally reported before was found. Some of hosts, such as *Aeschynanthus* sp., which are very economic important, *frequently suffered* from *Phytophthora*'s destroy under moist conditions. *Aeschynanthus* sp. and chincherinchees were found to be infected by *P. parasitica* in the fields in Changhua and Taichung, respectively (Figs. 5 & 6). The affected tissues, including leaf, stem, and root systems, were brown or black discoloration and appeared as leaf droop, stem shrunk and root rot. Eventually, the affected plants wilted and died. Six A^1 & four A^2 isolates and four A^2 isolates were obtained from these two crops, respectively. These isolates had mosaic spot mycelial patterns on 5% V-8 agar plate. They produced abundant non-deciduous sporangia with semi-spherical papilla in water as well as spherical chlamydospores on agar plates. The main characteristics of these isolates were listed on Table 2. Both crops showed high susceptibility to the fungus in the pathogenicity study. Most (>80%) inoculated one to three-month-old plants were killed within 2 weeks after spraying with zoospore suspension (about 10^6 zoospores/ml) of their respective host isolates and *P. parasitica* was reisolated from affected tissues.

On bougainvillea (Fig. 7), flame vine and desert rose (Fig. 8), *P. parasitica* caused serious blossom rot as well as leaf and bud blight during long periods of rainfall. All affected leaves and flowers fell eventually. Two A^1 and five A^2 isolates of *P. parasitica* were obtained from diseased bougainvillea locating in Taipei and Taichung, respectively. Whereas the 4 flame vine isolates from Chiayi were A^2 type and the 2 desert rose isolates from Taichung were A^1 type. Pathogenicity of them to their respective hosts was proved via inoculation and reisolation study. Results showed that young shoots of the three crops were highly susceptible to the fungus and all inoculated tissues collapsed within 7 days. Leaf and stem blight of an *Aphelandra* sp. was found at Tianwei, Changhua and 5 A^2 isolates of *P. parasitica* were obtained. *Aphelandra* was susceptible to the fungus in pathogenicity test. Serious *Phytophthora* root rot of Hawaiian hibiscus was found in two fields in Taichung and Chiayi (Figs.9 & 10). Eight isolates of *P. parasitica* belong to A^1 mating type were obtained. Sixty to eighty percents of three-month-old cuttings of Hawaiian hibiscus were killed within 2 months when roots of plants were dipped in zoospore suspension (about 10^6 zoospores/ml) for 24 hr and replanted in potted soil. The major characteristics of all isolated isolates from the five crops were listed on Table 2.

All A^1 isolates obtained in this study belong to Ko's sexuality type S1 and all A^2 isolates belong to S4 type [23].

Diseases caused by *P. palmivora* (Butler) Butler (on curcuma 薑荷花 and garden petuniain 矮牽牛)

Phytophthora palmivora was found to incite blossom blight of curcuma and wilt of garden petuniain in the fields after continuous rain. The affected flowers of curcuma showed discoloration in the early stage of infection and completely rotted eventually. One A^1 isolate of the fungus was isolated by Dr. Heish, T. F. in Chiayi. In the fields, the pathogen attacked whole plants of garden petunia during rain seasons. Phytophthora blight was initially appeared as water soaked spots on the infected leaves and stems of the crop. The affected tissues turned dark brown later and the whole plants drooped, fell and died eventually. Four A^2 isolates of *P. palmivora* were isolated in a garden in Chiayi. These isolates formed abundant sporangia on 5% V-8 agar. Sporangiophores branch simple sympodially. Sporangia have semi-spherical papilla and are deciduous with very short pedicels (< 5 μm). The main characteristics of these isolates were listed on Table 2. Flowers of curcuma and one-month-old seedlings of garden petunia were inoculated with zoospore suspension (10^6 spores/ml). Disease symptoms similar to those appearing in natural conditions were reproduced, and the same fungus was reisolated from all affected disease tissues. All A^1 isolates obtained in this study belong to Ko's sexuality type S1 and all A^2 isolates belong to S4 type [23].

DISCUSSION

The genus *Phytophthora* deBary has been reported as the main causes of many serious crop diseases in the world [18] including Taiwan [20]. Although many ornamental plants have been recorded as the hosts of *Phytophthora* species in Taiwan, the fungal species attacking new host crops was still observed in natural conditions frequently. In the study 16 Phytophthora diseases of flowering potted crops, which have not been formally reported, were found. Base on the survey data, 11 of them were found to be infected by *Phytophthora* for the first time in Taiwan. These crops included begonia, Taiwan pleione, cyclamen, bougainvillea, Hawaiian hibiscus, *Aeschynanthus* sp., *Aphelandra* sp., desert rose, chincherinchees, curcuma, and garden petunia. However, other four crops including azalea, anthurium, periwinkle and sweet alyssum have been records as hosts of *Phytophthora* already. Azalea was reported to be attacked by *P. cinnamomi* and other three crops were affected by *P. parasitica* [20] before. Whereas, *P. capsici* was detected on the diseased tissues of azalea, *P. citrophthora* on anthurium and periwinkle, and *P. cryptogea* on sweet alyssum in this study. Among these 16

圖五至圖十： *Phytophthora parasitica* 引起五種盆花疫病之病徵。口紅花萎凋 (圖五)；天鵝絨莖基部與葉片腐敗 (圖六)；九重葛花腐 (圖七)；沙漠玫瑰葉片腐敗 (圖八)；夏威夷朱槿地上部黃萎 (圖九) 與根系嚴重腐敗 (圖十)。

Figs. 5-10. Disease symptoms of the flowering potted crops caused by *Phytophthora parasitica*. Wilt of *Aeschynanthus* sp.(Fig. 5); Basal stem and leaf blight of *Ornithogalum ixias* (Fig. 6); Blossom blight of *Bougainvillea* sp. (Fig. 7); Leaf blight of *Adenium obesum* (Fig. 8); Leaf yellowing (Fig. 9) and root rot of *Hibiscus rosa-sinensis* (Fig. 10).

new diseases, *P. capsici* on azalea, *P. cinnamomi* on begonia, *P. citricola* on Taiwan pleione, *P. citrophthora* on anthurium, *P. cryptogea* on sweet alyssum, *P. parasitica* on *Aeschynanthus* sp., chincherinchees, flame vine and desert rose, and *P. palmivora* on curcuma have not been described in any other place previously. For the rests, disease symptoms were similar to those published in other countries [17,18].

Most of these host flowering plants, except chincherinchees, *Aeschynanthus* sp., *Aphelandra* sp. and curcuma, have been cultivated in Taiwan for a long time, but *Phytophthora* diseases of these plants were noticed and become serious recently. The climate factors in Taiwan were favorable to develop Phytophthora diseases. I suspected that one of reasons is due to the pathogens - *Phytophthora* may coming along with the imported plants. In this study, *Phytophthora capsici* was detected directly on the import azalea plants. Another possibility is that most of the tested introduced plants were highly susceptible to the Phytophthora species. According to previous reports, *P. parasitica* and *P. palmivora* were the two most common and destructive species in the genus of *Phytophthora* in Taiwan [15,19,20]. Most tested isolates of *P. parasitica* obtained from different host plants could cause severe diseases on other hosts in cross-inoculation studies (3,10 & unpublished data). These diverse sources of inocula, susceptible plants and moist climate conditions may be the principal factors contributing to the seriousness of *Phytophthora* diseases of flower plants in Taiwan.

The azalea isolates of *P. capsici* are not pathogenic to pepper. Some important morphological and physiological characteristics of the tested isolates (Table 2) are different from the *P. capsici* described by Leonian [27], but are similar to the carnation isolate from Hawaii [10] as well as those non-Solanaceous isolates from New Mexico [33]. Therefore, the fungus is categorized to an atypical type of *P. capsici* [33]. The azalea isolates produced deciduous sporangia with pedicels about 50 µm long, which were much longer than those of typical isolates (about 10-20 µm) were. All isolates belong to

A^o type, which did not form oospores singly or paired with both mating types of *P. parasitica*. Whereas all typical type isolates from pepper [28], carnation [10], and baby's breath [11] in Taiwan are A^1 and formed selfing-oospores. The maximum growth temperatures for the azalea isolates were 32-33 ℃, whereas the typical type isolates were 36-37 ℃.

Some important characteristics of the *P. cinnamomi* isolates obtained from begonia were not identical to those of the typical type of *P. cinnamomi* Rands [34,35]. Morphological characteristics, such as non-papillate and non-deciduous sporangia, and coralloid hyphal swellings in clusters, were similar to those of the typical type. However, same as most of Taiwanese citrus isolates [8], the cultures of begonia isolates formed a few sporangia but no chlamydospores on V-8 agar. They did not produce or produced only few selfing-oospores when paired with A^2 of *P. parasitica*, whereas typical type produced abundant oospores under same conditions. Meanwhile, the maximum growth temperatures for the begonia isolates were 36 ℃, whereas the typical type isolates were 32-33 ℃. Therefore, the begonia isolates were categorized to an atypical type of *P. cinnamomi*, which were similar to the citrus isolates in Taiwan [8].

The characteristics of the isolates of *P. citricola* from Taiwan pleione conform to those of Taiwanese citrus isolates of the same fungus [1]. All isolates produced semi-papillate, ovoid to irregular sporangia and formed abundant oospores singly (homothallic). All tested isolates grown on 5% CV-8 agar plates formed white colonies with radiate or chrysanthemum patterns. The maximum growth temperatures on 5% CV-8 agar were about 32-33 ℃. Therefore, the pleione isolates belonged to typical *P. citricola* [30].

The major characteristics of the tested isolates of *P. citrophthora* obtained from anthurium, periwinkle and cyclamen in this study (Table 2) were similar to those of the same fungal species in Taiwan [1]. They produced papillate and partially deciduous sporangia with a pedicel about 5-20 μm long. Selfing-oospores did not formed when cultured singly or paired with both mating types of *P. parasitica.* But they could stimulate A^2 of *P. parasitica* to form oospores. Therefore, the isolates belong to A^1 mating type of the sexuality type S3 [22,23]. All tested isolates formed white colonies with radiate patterns on 5% CV-8 agar plates. The maximum growth temperatures on 5% CV-8 agar were about 32-33 ℃. Therefore, all isolates were typical *P. citrophthora*.

The major characteristics of the isolate of *P. cryptogea* from sweet alyssum (Table 2) conform to those of the same species of fungus attacking carnation [10] and gebera [6] in Taiwan. The isolate produced non-papillate and non-deciduous sporangia. It did not form selfing-oospores when cultured singly or paired with both mating type of *P. parasitica*. But they belong to A^1 mating type of the sexuality type S3 [22,23] due to can stimulating A^2 of *P. parasitica* to form oospores. The fungus formed white colonies without patterns on 5% CV-8 agar plates. The maximum growth temperatures were about 32-33 ℃. The isolate of sweet alyssum is typical *P. cryptogea.*

All tested isolates of *P. parasitica* from the seven potted flowering plants were similar each other (Table 2) as well as were similar to those isolates obtained from citrus [1], carnation [10], lily [13], orchids [5] and potted flowers [2], etc, previously. The pathogens were not pathogenic to tobacco (unpublished data). All isolates produced spherical chlamydospores and hyphal swellings on agar medium. They formed unsymmetrically spherical to ovoid, papillate and non-deciduous sporangia with a shorter L/W (length/width) ratio of about 1.2-1.4. These isolates belong to cross-inducing (heterothallic) type, which do not form oospores when cultured singly. They were either A^1 mating type of the sexuality type S4, which could be stimulated by A^2 and induce A^2 type of *P. parasitica* to form oospores, or A^2 of S1 type, which could be stimulated by A^1 and induce A^1 type to form oospores [22,23]. All tested isolates grown on 5% CV-8 agar formed white colonies with patterns of scatter mosaic spots and a few scantly aerial mycelia. The maximum growth temperatures on 5% CV-8 agar were about 36-37 ℃. Therefore, all Taiwanese isolates of *P. parasitica* causing diseases of the seven flowering plants have all the characteristics of typical *P. parasitica* (Table 2) [31] based on Tucker's descriptions [32].

Similarly, all isolates of *P. palmivora* from curcuma and garden patunia were similar to those the same fungal species obtained in Taiwan previously [1,4,5]. Their characteristics conformed to the fungus described by Bulter (Table 2) and belong to typical type [31,35]. All of them formed white smooth colonies without patterns on 5% CV-8 agar plates. The maximum temperature for mycelial growth was 35 ℃. They produced spherical chlamydospores as well as hyphal swellings both under liquid and solid conditions. The fungus formed symmetrically spherical to ovoid, papillate and deciduous sporangia on agar medium with a short pedicel about 2-5 μm long.

Among the seven species of *Phytophthora* incited new diseases of flower crops, all isolates of *P. citricola*, *P. cryptogea*, *P. parasitica*, and *P. palmivora* belong to the typical types due to their major characteristics, which conform to the same species described by the first nominators. Whereas, *P. capsici* from azalea as well as *P. cinnamomi* from begonia were different from those typical types of the same species in many important characteristics. For those isolates belonging to atypical types, pathogenicity tests and molecular level studies may supplying more information for pathogen understanding in detail was needed in future.

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摘 要

安寶貞. 2000. 台灣盆花植物疫病之新紀錄. 植病會刊 9:1-10. (台中縣霧峰鄉 農業試驗所植物病理系；電子郵件 pjann@wufeng.tari.gov.tw，傳真 04-3338162)

自 1989 ~ 1999 年調查台灣花卉作物疫病時，發現有十六種未曾正式報告之盆花疫病，分述如下。一種非標準型的 *Phytophthora capsici* 引起西洋杜鵑萎凋與死亡。 *P. citrophthora* 感染火鶴花與日日春全株，及仙克來的根系與莖基部。 *P. parasitica* 危害七種盆花植物，包括單葯花 (全株萎凋腐敗)、九重葛 (葉片與花器腐敗)、夏威夷朱槿 (根腐)、炮仗花 (葉片與花器腐敗)、沙漠玫瑰 (幼嫩組織與經部腐敗)、天鵝絨 (全株萎凋與腐敗) 及口紅花 (萎凋)。而 *P. palmivora* 則造成薑荷花花器腐敗與矮牽牛萎凋。此外，非標準型的 *P. cinnamomi* 自四季秋海棠的腐敗莖基部， *P. citricola* 從台灣一葉蘭的罹病葉片，及 *P. cryptogea* 自香雪球的罹病根系組織中分離得到。這些寄主植物在接種個別分離得到的疫病菌遊走子懸浮液後，都出現與田間自然發病時相同的病徵，而且相同的疫病菌亦均自發病組織回分得到。這些新病害中， *P. capsici* 危害西洋杜鵑、 *P. cinnamomi* 危害秋海棠、 *P. citricola* 危害台灣一葉蘭、 *P. citrophthora* 危害火鶴花、 *P. cryptogea* 危害香雪球， *P. parasitica* 危害口紅花、天鵝絨、炮仗花及沙漠玫瑰、以及 *P. palmivora* 危害薑荷花在世界其他各地均尚未發表過。

關鍵詞： 疫病、疫病菌、新紀錄、 P*hytophthora capsici, P. cinnamomi, P. citricola, P. citrophthora, P. cryptogea, P. parasitica, P. palmivora* 、盆花植物