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Phytophthora Wilt of Carnation in Taiwan and Hawaii[1)]

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ABSTRACT

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Phytophthora parasitica, P. capsici, P. cryptogea and an undescribed species of *Phytophthora* were isolated from carnation in Taiwan. *P. capsici* and *P. cryptogea* were also isolated from carnation in Hawaii. All identified species of *Phytophthora* from Taiwan and Hawaii caused wilting of carnation seedlings in pathogenicity tests. *P. parasitica* isolated from other hosts and *P. capsici* from peppers were also pathogenic to carnation seedlings. *P. capsici* isolated from carnation in Taiwan caused wilt to peppers, while the isolate from Hawaii was nonpathogenic to peppers. Development of Phytophthora wilt of carnation was more rapid at 25-30°C than at 15-20°C for all of the three species of *Phytophthora* tested.

(Key words: Carnation, *Phytophthora*)

INTRODUCTION

Carnation (*Dianthus caryophyllus* L.) has become an important economic commodity in Taiwan in recent years. Currently, there are about 100 ha of carnation distributed mainly in the central and central-southern counties. The duration of a crop of carnation in Taiwan is less than one year due to infection by various pathogens. Most of the diseases occurred on roots and basal stems and caused wilting of the plants, similar to the diseases caused by *Phytophthora*.

Species of *Phytophthora* which have been recorded to be pathogens of carnation throughout the world include *Phytophthora cactorum* (L. & C.) Schroeter [19], *Phytophthora parasitica* Dastur[4], *Phytophthora palmivora* (Butler) Butler[1], *Phytophthora citricola* Sawada[7], and *Phytophthora porri* Foister[17]. During a

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survey conducted from July 1988 to September 1989, several species of *Phytophthora* were isolated from tissues of wilting carnation. Two species of *Phytophthora* were also isolated from wilting carnation in Hawaii at about the same time. In this paper, we report the identity of these *Phytophthora* and their pathogenicity to carnation.

MATERIALS AND METHODS

Isolation

Wilting carnation plants were collected from diseased fields. Pieces of tissues taken from stems or roots (ca. 10-15 mm) with advanced water soaking symptoms were disinfested with 0.5% NaClO for 5 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[16]. After incubation at 24°C for 1-2 days, mycelial mats of *Phytophthora* spp. growing out of diseased caranation 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 (about 5×5×3mm) 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 hours for sporangial formation, the cultures were placed at 15°C for 30 min and returned to ambient temperature for development and discharge of zoospores [13]. A drop of zoospore suspension was spread on a plate of water agar. After 24 hours, individual germinating zoospores were transferred to 5% V-8 juice agar plates. Single-zoospore isolates were used for this 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 simultaneous 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 back to 24°C for 30 min. Before being used for inoculation the suspension was passed through two layers of cheesecloth to remove the mycelia.

Determination of mating types

Each isolate of *Phytophthora* was grown on 10% V-8 juice agar (10% V-8 iuice, 0.02% $CaCO_3$, 2% Bacto agar) at 24°C in darkness for 10 days. Those individual isolates producing oospores by themselves under such conditions were 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 *Phytophthora parasitica* separately for determination of their mating types. A small piece of culture block (about 2×2×2 mm) of each isolate and the same size of tester were placed on opposing ends on a piece of 10% V-8 agar (about 15×10×2 mm) in Petri dishes (100 mm in diameter). Eight pieces of agar blocks were placed at equal distance along the perimeter of a Petri dish[3]. 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 being 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 being A^0 (sterile).

Production of oospores

The polycarbonate membrane method described by Ko[11] 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 the bottom of a Petri dish and aseptically covered with a sterile polycarbonate membrane (0.2 μm, 90 mm diameter; Nucleopore, Pleasanton, CA 94566, USA). The myceial surface of an 1-day-old culture block of 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 under the same conditions for another 6 days, presence of oospores on the surface of the lower agar blocks was examined microscopically.

Growth of *Phytophthora*

Phythophthora isolates were grown on 5% clarified V-8 juice agar for 3-5 days. Agar discs (5 mm in diameter) cut from the periphery of the colonies with a sterile cork borer were used to inoculate plates. One agar disc inoculum was transferred onto the edge of a 5% clarified V-8 agar plates. To determine the effect of temperature on the growth of each *Phytophthora* spp., inoculated agar plates were incubated at 10, 12, 15, 20, 25, 28, 30, 33, 35 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 (Ho[9], Newhook *et al*[20], and Waterhouse[25]) and original descriptions[26] were used for identification of the *Phytophthora* isolates obtained. Morphological and physiological characteristics of each culture were compared with those described in taxonomy papers.

Chlamydospore formation by *P. capsici*

Pepper and carnation isolates of *P. capsici* from Taiwan and Hawaii were grown on 10% V-8 juice agar at 24°C in darkness for 1 week. Five pieces of the mycelial mats (10×10×3mm) of each culture were cut and transferred into a glass Petri plate. Simultaneously a soil extract was prepared by mixing 20 g of Typic Hydrandep soil with 100 ml of water and allowing it to stand for 3 hours with periodic shaking. The soil-water mixture was filtered through a Whatman No. 1 filter paper. Ten ml of the soil extract was pipetted into the Petri plate containing the culture agar blocks and incubated in darkness for another 3 days. The agar surface was examined with a microscope for the presence of chlamydospores.

Pathogenicity tests

Three or four isolates per *Phytophthora*

species were selected for pathogenicity tests. Four isolates of *Phytophthora capsici* from pepper (*Capsicum annum* L.) were also used. Zoospore suspension used as inoculum was adjusted to 10^5 zoospores/ml with microliter syringe method[15]. One month old carnation seedlings established from cuttings in pots (9×9×9 cm) were inoculated by dispensing 0.5 ml of zoospore suspension on a small piece of sterile cotton placed around the stem bases. Three seedlings were inoculated for each treatment and tests were repeated three times. For inoculation of 15-day-old seedlings established from seeds in pots, two drops of zoospore suspension were pipetted onto the soil surface adjacent to the stem of each young seedling. Ten seedlings were used for each isolate. Controls for each test were similarly treated with distilled water. After incubation at 24°C for 3 days, wilting seedlings were counted every 3 days. The wilting plants were removed from soils, disinfested with 0.5% NaClO for 3 min and plated on the selective medium described above for reisolation of the organisms. To determine the pathogenicity of *Phytophthora* spp. to other parts of the carnation plants of which infection was not observed in the fields, small pieces of sterile cotton, containing two drops of zoospore suspension, were placed on flowers, leaves, and stems.

Zoospore suspensions of *P. parasitica* obtained from citrus, pineapple, passion fruit, papaya, guava, baby's-breath, dendrobium, lily, and Christmas cactus were also prepared and used to test their pathogenicity on carnation as described above. Six carnation seedlings established from cuttings were used for each isolate and data were recorded every three days.

For inoculation of pepper, 15-day-old seedlings established from seeds were used. Two drops of zoospore suspension of the tested isolates were placed on the basal stems on the soil line. Disease incidence was recorded as described above for carnation.

RESULTS

Symptoms

Tissues of carnation infected by *Phytophthora* spp. became bleached, water soaking and collapsed (Fig. 1-A). All *Phytophthora* infected plants eventually died due to severe stem and root rot. *Phytophthora* spp. could kill carnation at every growing stage from young seedlings to flowering plants in the fields. Phytophthora wilt of carnation was very serious during the wet seasons especially during typhoon seasons in Taiwan. During continuous rain, *Phytophthora* spread rapidly and more than 20% of carnation plants were infected and died within a very short period of time (Fig. 1-B).

Distribution of *Phytophthora* spp. in carnation field

A total of 228 isolates of *Phytophthora* were obtained from 226 diseased plants in 70 carnation fields in Taiwan (Table 1). One isolate of *P. capsici* and one isolate of *P. cryptogea* were obtained from carnation at Wood Valley, Hawaii in 1985. All of them were isolated from basal stem tissues of diseased plants.

Four species of *Phytophthora* were isolated from carnation in Taiwan including 165 isolates of *P. parasitica* Dastur

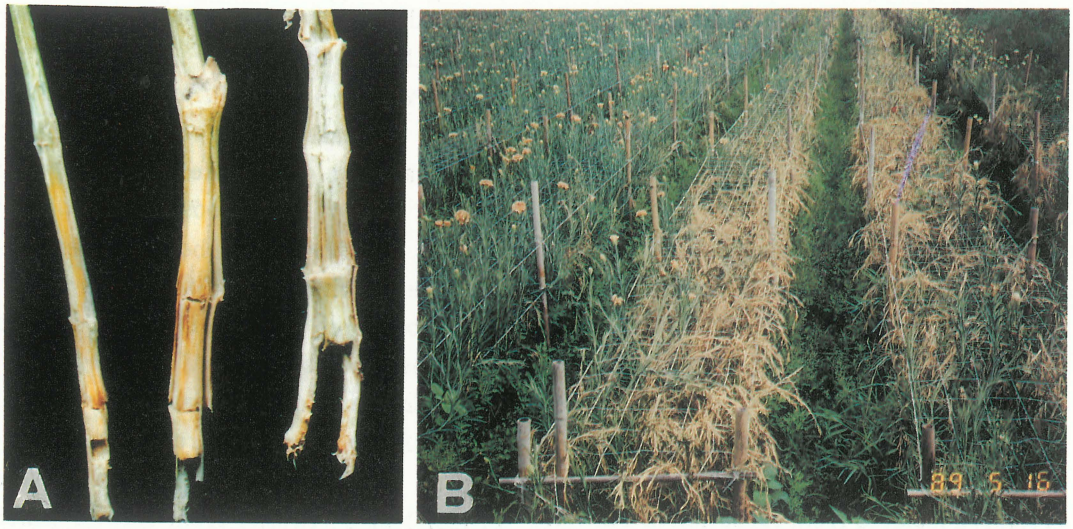


Fig. 1. Phytophthora wilt of carnation. A. Diseased stems of carnation. B. Diseased carnation in the orchard.

Table 1. Isolation of *Phytophthora* species from carnation in Taiwan

Location	No. of samples investigated	No. of samples with *Phytophthora*			
		P. parasitica	*P. capsici*	*P. cryptogea*	Undescribed species
Chia Yi					
Chia Yi	329(69)[1)]	130(37)	3(3)	9(7)	30(14)
Chang Hua					
Tien wei	29 (5)	16 (5)	0	0	0
Taichung					
Holi	21 (4)	2 (1)	2(1)	0	0
Nantow					
Puli	57(16)	3 (2)	17(6)	0	0
Shin Yi	42 (9)	14 (5)	2(1)	0	0
Fu Hsing	5 (1)	0	0	0	0
Total	483(104)	165(50)	24(11)	9(7)	30(14)

1) The first figures refer to numbers of plants; the second, in parenthesis refer to numbers of fields.

(14 A^1:151 A^2), 24 isolates of *P. capsici* Leonian (all A^1), 9 isolates of *P. cryptogea* Pethybridge & Lafferty (all A^1) and 30 isolates of undescribed species (Table 1). *P. parasitica* was present in 50 carnation fields at 4 counties, and *P. capsici* was detected in 11 carnation fields at 3 counties. *P. cryptogea* and the undescribed species were isolated from 7 and 14 fields in Chia Yi city, respectively. Usually only one species of *Phytophthora* could be isolated from each diseased plant and affected field. However, two different species were detected in each of 12 fields

of which two different species were detected on individual plant in 2 fields. Meanwhile both A^1 and A^2 types of *P. parasitica* were isolated from different plants within the same field at Shin Yi, Nantou.

Symptoms of carnation wilt caused by the four *Phytophthora* species were similar on artificially inoculated plants as well as naturally infected plants in the fields.

Characteristics of *Phytophthora* spp.

Only *P. parasitica*, *P. capsici* and *P. cryptogea* isolated from carnation in Taiwan and the later two species from Hawaii were studied. All of the tested isolates belong to cross-inducing (Heterothallic) species which did not form oospores when cultured individually. Most of isolates of *P. parasitica* were of the A^2 mating type. Few isolates of *P. parasitica*, all of the isolates of *P. capsici* and *P. cryptogea* obtained in Taiwan were of the A^1 mating type. All of the tested A^1 isolates of *P. parasitica* and *P. capsici* belong to the sexuality type $S^{1(12,14)}$ because they can be stimulated by A^2 and induce A^2 to form oospores. All A^1 isolates of *P. cryptogea* belong to sexuality type S^2 which can stimulate A^2 to form oospores but can not produce oospores themselves. A^2 isolates of *P. parasitica* can be stimulated by A^1 and induce A^1 to form oospores, thus belonging to sexuality type S^4. The isolate (P129F) of *P. capsici* from Hawaii which did not form oospores when paired with either A^1 or A^2, belonging to type S^{16} (A^0).

Large amount of sporangia from tested isolates of *Phytophthora* were produced on mycelial mats using the method developed by Hwang *et al*[10]. The shape and size of sporangia varied

Table 2. Characteristics of sporangia of *Phytophthora* spp. from carnation

Species & isolate	Mating type	Location	Size of sporangia (μm)			Length of pedicel (μm)
			Length	Width	L/W	
P. parasitica						
PPCa-3	A^2	Chia Yi	42-62(52.7)	37-49(41.8)	1.01-1.36(1.26)	
PPCa-12	A^1	Chia Yi	40-70(53.0)	30-50(41.3)	1.11-1.59(1.29)	
PPCa-34	A^1	Sin Yi	40-60(47.6)	28-45(37.4)	1.00-1.57(1.27)	
P. capsici						
PCaC-1	A^1	Puli	40-66(54.1)	31-48(40.6)	1.25-1.80(1.34)	17-96(34)
PCaC-4	A^1	Chia Yi	30-90(49.9)	25-48(38.2)	1.04-2.00(1.31)	10-86(31)
PCaC-10	A^1	Holi	31-81(53.4)	24-60(38.2)	0.97-2.46(1.45)	24-162(48)
P129F	A^0	Hawaii	33-65(53.4)	25-32(28.1)	1.44-2.41(1.90)	39-203(77)
P. cryptogea						
PCrC-1	A^1	Chia Yi	32-64(48.3)	24-45(42.0)	1.07-2.04(1.53)	
PCrC-3	A^1	Chia Yi	35-73(55.5)	29-40(35.2)	1.01-1.83(1.57)	
PCrC-7	A^1	Chia Yi	41-63(47.7)	28-40(33.4)	1.29-1.69(1.46)	
PCry2	A^1	Hawaii	35-64(52.8)	30-40(34.8)	1.15-1.85(1.51)	

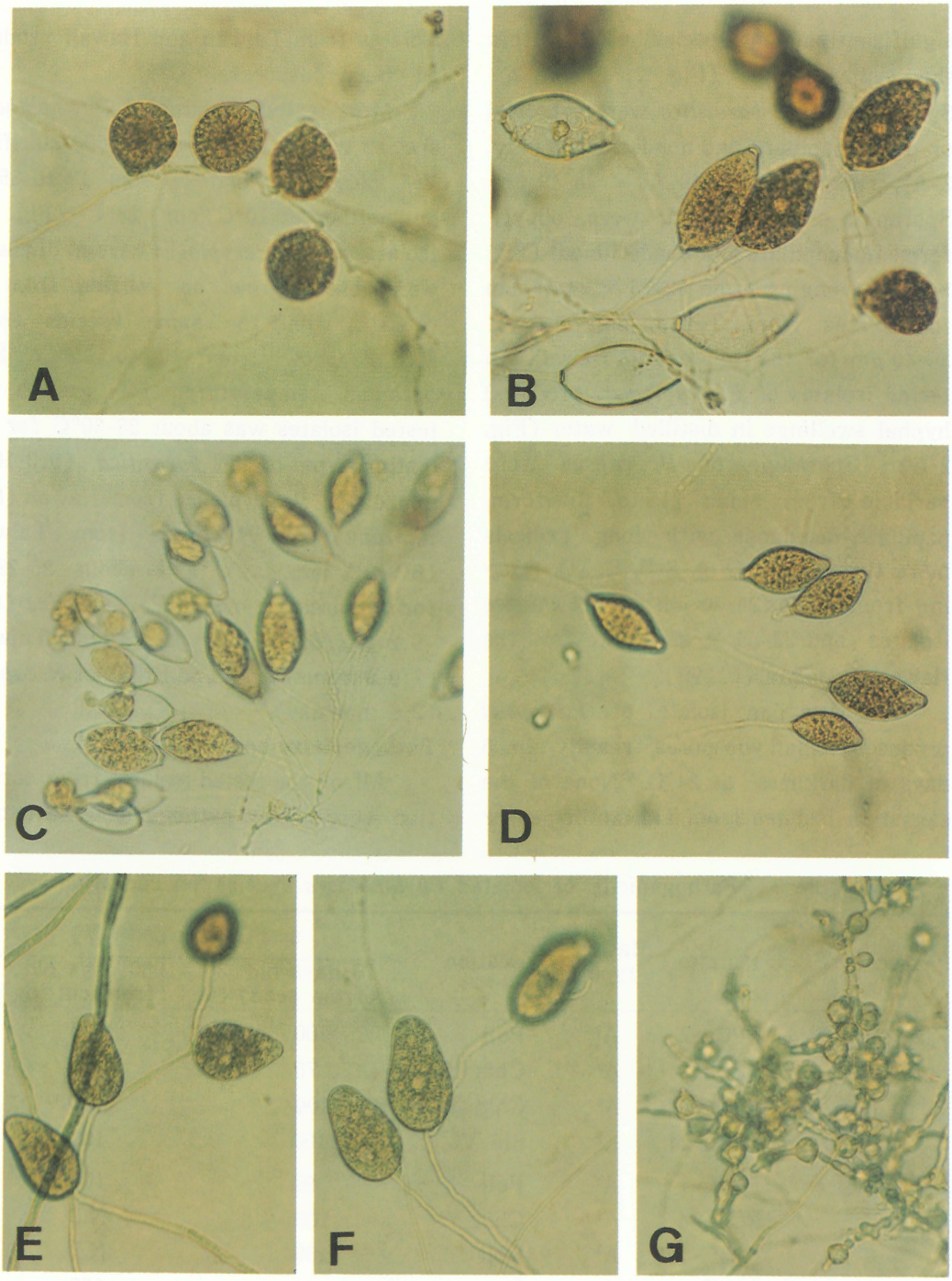


Fig. 2. Morphological characteristics of *Phytophthora* spp. isolated from carnation (X170). A. sporangia of isolate PPCa-3 of *P. parasitica*. B. sporangia of isolate PCaC-1 of *P. capsici* from Taiwan. C-D. Sporangia of isolate P129F of *P. capsici* from Hawaii. E. Sporangia of isolate PCrC-1 of *P. cryptogea* from Taiwan. F. Sporangia of isolate PCry 2 of *P. cryptogea* from Hawaii. G. Hyphal swellings of isolate PCrC-1 of *P. cryptogea* producing in sterile distilled water.

significantly among species but not within the same species (Fig. 2, Table 2). Sporangia of *P. parasitica* were spherical or ovoid, papillate and nondeciduous (Fig. 2-A), ranging from 40-75 × 28-49 μm. Sporangia of *P. cryptogea* were obpyriform, nonpapillate and nondeciduous (Fig. 2-E, F), ranging from 32-73 × 24-45 μm for isolates from Taiwan and 35-64 × 30-40 μm for the isolate from Hawaii. All tested isolates of *P. cryptogea* produced hyphal swellings in distilled water (Fig. 2-G). Sporangia of *P. capsici* were variable from spherical to fusiform, papillate, deciduous with long pedicels more than 20 μm (Fig. 2-B, C, D), ranging from 30-90×24-60 μm for Taiwanese isolates and 33-65 × 25-32 μm for the Hawaiian isolate (P129F).

The Hawaiian isolate of *P. capsici* produced chlamydospores readily in 3 days of darkness at 24°C. None of the carnation isolates from Taiwan or pepper isolates from Taiwan and Hawaii produced chlamydospores.

Most tested isolates of *Phytophthora* species were able to grow on 5% clarified V-8 juice agar plates from 12 to 35°C but neither at 10°C nor 38°C (Fig. 3). Isolates of *P. cryptogea* from Taiwan were able to grow on medium from 10 to 33°C, while the same species from Hawaii grow from 10 to 35°C. The optimum temperature for growth of tested isolates was about 28-30°C for A^1 mating type of *P. parasitica* (9.3-10.6 mm/day), *P. cryptogea* from Hawaii (8.2 mm/day), and *P. capsici* from Taiwan (8.3-9.2 mm/day), and about 25-28°C for A^2 mating type of *P. Parasitica* (8.0 -9.2 mm/day), *P. cryptogea* from Taiwan (7.0-9.2 mm/day), and P129F of *P. capsici* (9.6 mm/day).

Pathogenicity tests

All of the tested isolates from carnation were highly pathogenic to carnation

Table 3. Pathogenicity of isolated *Phytophthora* species on carnation

Species	Isolate	Mating type	Location	seedlings killed (%)	
				15 days old (from seed)	30 days old (from cutting)
P. parasitica	PPCa-2	A^2	Puli	100	100
	PPCa-3	A^2	Chia Yi	75	94
	PPCa-12	A^1	Chia Yi	100	N.D.[1)]
	PPCa-34	A^1	Sin Yi	100	100
P. capsici	PCaC-1	A^1	Puli	95	100
	PCaC-4	A^1	Chia Yi	100	N.D.
	PCaC-10	A^1	Holi	100	N.D.
	P129F	A^0	Hawaii	95	100
P. cryptogea	PCrC-1	A^1	Chia Yi	100	100
	PCrC-3	A^1	Chia Yi	100	100
	PCrC-7	A^1	Chia Yi	100	N.D.
	PCry2	A^1	Hawaii	90	84

1) N.D., Not determined.

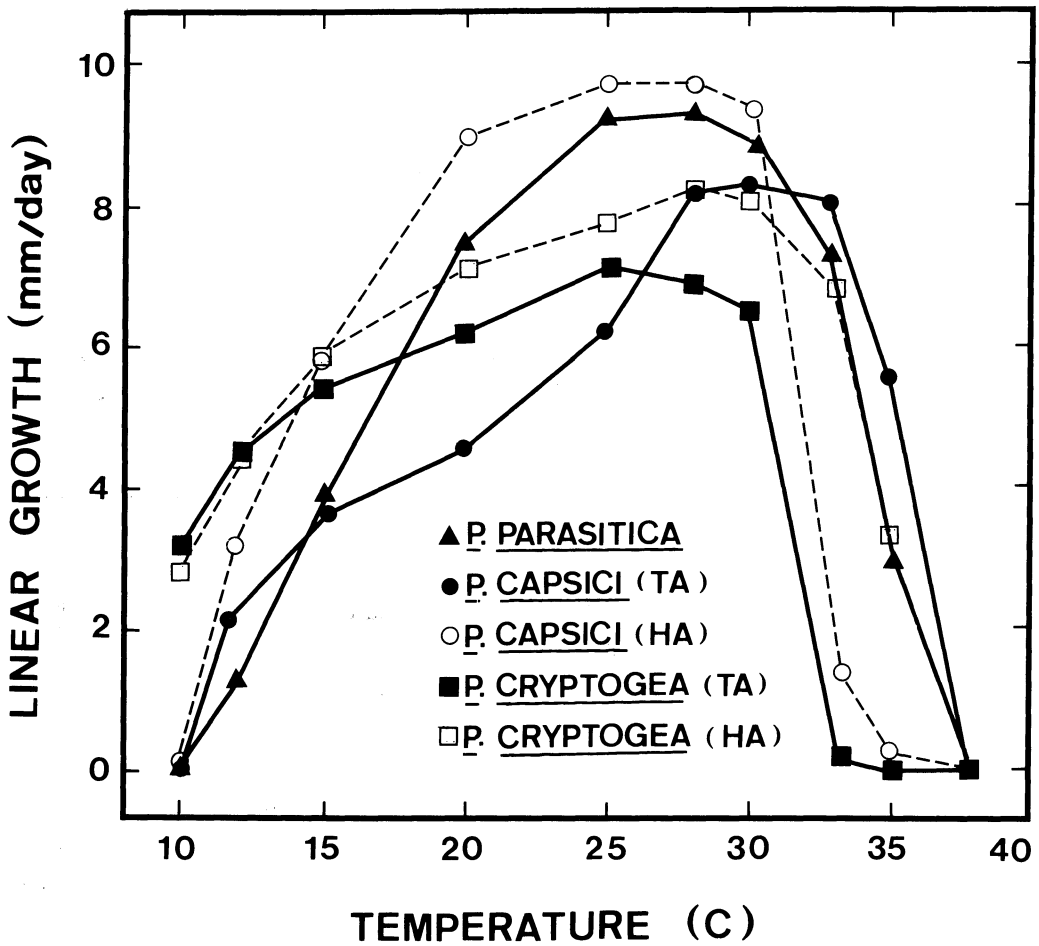


Fig. 3. Growth of isolates of *Phytophthora* spp. from carnation on 5% clarified V-8 juice agar plates at various temperatures. ▲: Isolate PPCa-3 of *P. parasitica*; ●: Isolate PCaC-1 of *P. capsici* from Taiwan; ○: Isolate P129F of *P. capsici* from Hawaii; ■: Isolate PCrC-1 *P. cryptogea* from Taiwan; □: Isolate PCry-2 of *P. cryptogea* from Hawaii.

(Table 3). Symptoms produced under natural field conditions also appeared on seedlings about 2-4 days after inoculation. Most seedlings died within 2 weeks after the appearance of the initial symptoms. All of the tested isolates of the three species of *Phytophthora* also attacked flowers, leaves, and stems of carnation plants. More than 90% of the inoculation tests were successful. Bleaching followed by droopiness were symptoms produced on leaves and stems, while bleaching and browning were the main symptoms on flowers.

All tested isolates of *P. parasitica* obtained from other hosts were able to cause death of 1-month-old seedlings of carnation in pathogenicity tests. Seedlings died after inoculation with isolates of citrus (67%), pineapple (50%), passion fruit (50%), papaya (100%), guava (67%), baby's-breath (33%), dendrobium

Table 4. Cross-inoculation of *Phytophthora capsici* obtained from carnation and pepper

Isolate	Mating type	Host	Location	Seedlings killed (%)	
				Carnation	Pepper
PCaC-1	A^1	Carnation	Puli	95	94
PCaC-4	A^1	Carnation	Chia Yi	100	100
PCaC-10	A^1	Carnation	Holi	100	100
P129F	A^0	Carnation	Hawaii	90	0
PCa-11	A^1	Pepper	Liu Chiao	80	95
PCa-12	A^1	Pepper	Yuan Chang	95	94
PCa-17	A^1	Pepper	Kaosu	100	96
P287[1)]	A^1	Pepper	Hawaii	100	92

1) Isolate of P287 was obtained from Dr. Aragaki.

(67%), lily (100%), and Christmas cactus (67%). *P. capsici* isolated from pepper and carnation in Taiwan were highly pathogenic in reciprocal pathogenicity tests. However, the Hawaiian isolate of *P. capsici* from carnation failed to produce disease symptoms on inoculated 15-day-old pepper seedlings (Table 4).

Higher temperature (25-30°C) was more favorable to development of carnation wilt than lower temperatue (15-20°C) (Table 5). About 90-100%, 90-100%, and 100% of 15-day-old carnation seedlings were killed within 2 weeks at 25-30°C by *P. parasitica*, *P. capsici*, and *P. cryptogea*, respectively; only 17-50%, 36-40%, and 13-60% of inoculated seedlings were killed by those respective fungi at 15-20°C.

Table 5. Effect of temperature on development of Phytophthora wilt on carnation

Species	Isolate	Seedlings killed (%)	
		15—20°C	25—30°C
P. parasitica	PPCa-3	17	90
	PPCa-34	50	100
P. capsici	PCaC-1	36	100
	PCaC-10	40	100
	P129F	38	90
P. cryptogea	PCrC-1	13	100
	PCrC-3	14	100
	PCry2	60	100

DISCUSSION

Prior to our report five species of *Phytophthora* have been reported to be pathogens of carnation. They are *P. cactorum* (also reported as *P. omminivora* [19]), *P. parasitica* (also reported as *P. nicotianae*[21] and *P. parasitica* var. *macrospora*[22]), *P. citricola*[7], *P. palmivora*[1] and *P. porri*[17]. All of these organisms have not been isolated in this study except for *P. parasitica*. *P. capsici* and *P. cryptogea* appear to be previously undescribed pathogens of carnation.

Among the four species of *Phytophthora* isolated *P. parasitica* was the most widely distributed in the carnation fields in Taiwan. Based on the survey data, more than 70% of Phytophthora wilt of carnation were caused by this fungus (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[2,6]. Meanwhile, all tested isolates of *P. parasitica* obtained from other hosts were also pathogenic to carnation. This diverse source of inoculum may explain the seriousness of Phytophthora wilt of carnation in Taiwan. Carnation wilt caused by *P. parasitica* has also been reported in Hawaii[8].

Usually a single species of *Phytophthora* was isolated from individual carnation plant. However, two different species of *Phytophthora* were simultaneously detected in 2 plants. Also two different species of *Phytophthora* were frequently isolated from different plants in the same fields. Meanwhile isolates with opposite mating types of different species or the same species were present on the same plants or different plants within the same fields, indicating the possibility of sexual reproduction by these fungi in nature.

All of the carnation isolates of *P. capsici* produced deciduous sporangia with pedicels longer than 20 μm, an important morphological characteristic of the species. However, the Hawaiian isolate has longer pedicel and narrower sporangia than the Taiwanese isolates (Tables 2, 6). The Hawaiian isolate is also distinct from the Taiwanese isolates in its ability to produce chlamydospores and inability to attack pepper. Moreover, the mating type of the former is A^0, while that of the latter are A^1. The isolates from Taiwan, but not the one from Hawaii, have essentially all the characteristics of typical *P. capsici*[18,23,24].

Table 6. Comparison of *Phytophthora capsici* isolated from carnation in Taiwan an Hawaii

Characteristic	Taiwanese isolates	Hawaiian isolate
Average pedicel length (μm)	31-48	77
Average L/W of sporangia	1.31-1.45	1.90
Chlamydospore formation	No	Yes
Pathogenic to pepper	Yes	No
Mating type	A^1	A^0

The development of carnation wilt was more conducive at higher temperature (25-30°C) than at lower temperature (15 -20°C). This phenomenon appear to be related to the growth rates of *P. parasitica*, *P. capsici*, and *P. cryptogea* under the two ranges of temperature (Fig. 3).

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摘　　要

安寶貞[1]、Kunimoto, R.[2]、柯文雄[3]　1990　臺灣與夏威夷之康乃馨疫病　植保會刊 32：145～157　(1. 嘉義市臺灣省農業試驗所嘉義分所　2. 美國夏威夷大學植病系)

Phytophthora Parasitica, P. capsici, P. cryptogea 與一未知之疫病菌自臺灣之康乃馨上分離到。同時，*P. capsici* 及 *P. cryptogea* 亦從夏威夷之康乃馨上分得。在病原性測定試驗中，分得之 *P. parasitica, P. capsici* 及 *P. cryptogea* 均能感染康乃馨。而從其他寄主所分離之 *P. parasitica* 及甜椒上分離之 *P. capsici* 亦能引起康乃馨幼苗死亡。爲害臺灣康乃馨之 *P. capsici* 菌株可以感染甜椒幼苗，但夏威夷菌株則對甜椒無病原性。康乃馨幼苗在接種疫病菌後，其病勢進展在 25-30°C 較 15-20°C 爲迅速，病情亦較嚴重。

（關鍵字：康乃馨、疫病菌）