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PHYTOPHTHORA BLIGHT OF PIGEON PEA IN INDIA

J. KANNAIYAN

International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India

O. K. RIBEIRO, D. C. ERWIN

Department of Plant Pathology, University of California, Riverside, California 92521

AND

Y. L. NENE

International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India

SUMMARY

Isolations were made from blighted pigeon-pea *(Cajanus cajan)* plants from different locations in India. A species of *Phytophthora* was consistently obtained from these locations and was proved to be the causal organism involved in the disease. Based on the sporangium shape and size, oogonium and oospore formation, temperature requirements, and pathogenicity tests, we have classified these isolates as *P. drechsleri* f. sp. *cajani.* The use of formae speciales was considered appropriate because of the specificity of these isolates to pigeon pea and *Atylosia* spp., wild relatives of the pigeon pea.

A serious stem blight of pigeon pea [*Cajanus cajan* (L.) Millsp.] was first reported in India in 1966 (19). Since then the disease has spread to most pigeon-pea-growing areas in India, resulting in heavy economic losses (8, 18). Recently a similar disease caused by *Phytophthora parasitica* Dast. was reported on pigeon pea in Puerto Rico (6). Pal et al. (8) identified the causal organism as *Phytophthora drechsleri* Tucker var. *cajani* Pal, Grewal & Sarbhoy. A later investigation of the same disease in India by Amin et al. (1) resulted in the causal organism being reported as a new species of *Phytophthora, P. cajani* Amin, Baldev & Williams. To proceed with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) breeding program for resistance to this disease in pigeon-pea cultivars in India, it was important to resolve the confusion as to the identity of the causal organism

of blight of pigeon pea. We therefore undertook a detailed study of several isolates of *Phytophthora* from blighted pigeon-pea plants, including the isolate designated as *P. drechsleri* var. *cajani (8),* to determine critically whether one or more species of the genus was involved.

METHODS AND MATERIALS

The *Phytophthora* isolates used in this study were obtained from the following locations; P2 (Hyderabad), P3 (New Delhi); P4 (Kanpur), P5 (Kalyanpur), and P6 (Deeg). *Phytophthora drechsleri* var. *cajani* was obtained from the Indian Agricultural Research Institute, New Delhi type-culture collection. All isolates were maintained on potato-clextrose agar (PDA) or clarified V-8-juice agar (CV8A). These cultures have been deposited in the culture collections maintained by the Department of Plant Pathology, University of California, Riverside and by the Commonwealth Mycological Institute, Kew, England. Sporangia were obtained by transferring 5-mrn inoculum plugs from the outer edge of a 3 to 4-da-old growing colony on CV8A to Petri plates (5 cm in diam) containing 5 ml of diluted V-8 juice (1: 5) . The plates were then incubated under Westinghouse 40-watt fluorescent lamps at an intensity of 1,300 μWcm^2 (12 h light/12 h dark cycle), after which the medium was removed and replaced by fresh distilled water. The cultures were then incubated for a further 24-h period after which abundant sporangia were formed.

TABLE I

COMPARISON OF THE EFFECT OF TEMPERATURE ON RADIAL GROWTH OF ISOLATES OF *Phytophthora* (P2-P6) FROM *Cajanus* cajan with SEVERAL KNOWN SPECIES ON CLARIFIED V-8-JUICE AGAR[a]

Isolates	Temperature (C)[c]								
	5	9	15	*21*	24	27	30	33	36
P2	0	1	30	56	72	79	80	80	56
P3	0	3	32	57	71	79	80	79	48
P4	0	1	31	58	71	76	76	64	35
P5	0	1	28	56	66	74	72	63	37
P6	0	2	32	60	67	76	77	67	50
Phytophthora[b] *drechsleri* var. *cajani*	0	2	19	53	71	78	80	74	45
P. cryptogea.	8	19	41	64	69	68	41	7	0
P. drechsleri	2	15	3S	5S	65	70	68	68	34
P. megasperma	6	19	42	61	72	78	75	3	0
P. vignae	0	0	*21*	38	41	44	37	25	0

[a] Average of four replications.
[b] From Pal *et al.* (8).
[c] None of the isolates grew at 39 C.

TABLE II

COMPARISON OF THE SIZE OF SPORANGIA OF SEVERAL ISOLATES OF *Phytophthora* (μ2-p6) FROM *Cajanus cajan* WITH SEVERAL KNOWN *Phytophthora* SPECIES

Isolates	Size (μm)	L:B ratio
P2	42-83 (66) X 29-46 (37)	1.7:1
P3	50-76 (64) X 29-12 (36)	1.7:1
P4	46-74 (61) X 31-48 (40)	1.7:1
P5	48-64 (54) X 29-42 (35)	1.5:1
P6	50-73 (62) X 33-48 (38)	1.5:1
Phytophthora[b] *drechsleri* var. *cajani*	56-73 (64) X 32-46 (38)	1.6:1
P. cajani[c]	49-82 (60) X 19-44 (32)	1.7:1
P. cryplogea[d]	Average 37-40 X 23 (maximum 55 X 30)	1.7:1
P. drechsleri[d]	Average 36-50 X 26-30 (maximum 70 X 40)	—

a Data in parentheses are the means based on 50 measurements for each value.
b Pal et al isolate (8);
c From Amin et at. (1).
[d] From Waterhouse (16).

Observations on oogonial and antheridial formation were made on carrot-agar medium (9) and a modified CV8A which contained β-sitosterol (30 nig/liter), tryptophan (20 mg/liter), $CaCl_2$-H_2O (100 mg/liter), and thiamine (1 mg/liter) (4). ,A plug (5 mm diam) of each isolate was placed in 90-mm Petri dishes containing the solidified agar medium opposite (20 mm apart) to a 5-mm plug of the A^1 or A^2 mating type of either *P. drechsleri* Tucker (P10S7, A^2), *P. cinnamomi* Rands (Pc40, A^2 and Pcl 40, A^2), *P. cryptogea* Pethyb. & Laff. (P1016, A^2), or *P. cambivora* (Petri) Buisman (P592, A^2). All cultures were incubated at 25 C in darkness for 3 wk before observations were made.

For pathogenicity tests, a minced mycelium suspension was poured around the base of 7- to 10-da-old seedlings growing in a natural soil classified as alfisol (60% sand, 33% clay, 7% silt) and in UC mix (50% peat, 50% sand), contained in plastic pots (15 cm diam).

RESULTS

Morphological studies.—The morphology and growth rates of our isolates were studied on CV8A, at the following temperatures: 5, 9, 15, 21, 24, *27,* 30, 33, *36,* and 39 C. The optimum temperature for growth of all isolates was 27 to 33 C, minimum 9 C, and maximum 36 C. Comparative temperature studies were also made with type cultures of *P. drechsleri* (P1087), *P. cryptogea* (P1088), *P. megasperma* Drechs, (P1057), and *P. vignae* Purss (P606). Our isolates resembled the *P. drechsleri* type culture in optimum growth rate (TABLE I). Colony

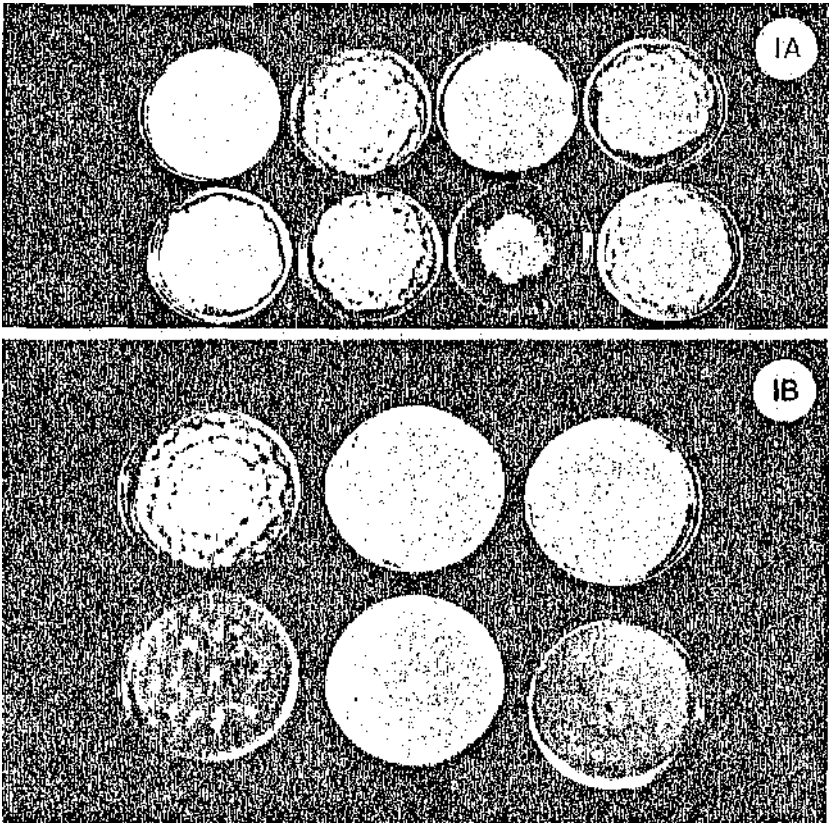

FIG. 1. A. Morphology of 7-da-old colonies of pigeon-pea *Phytophthora* isolates (L-R; top row) P2, P3, *P. drechsleri* var. *cajani,* P4; (L-R; second row) PS, P6, *P. cryptogea* and *P. drechsleri* at 30 C on PDA (potato-dextrose agar). B. Colony morphology of one pigeon-pea *Phytophthora* isolate (P3) at 30 C on different media. (L-R; top row) PDA (potato-dextrose agar); V8A (regular V-8-juice agar); CV8A (clarified V-8-juice agar); (L-R; second row) CMA (cornmeal agar); OMA (oatmeal agar); and LBA. (lima-bean-agar)

morphology varied considerably on PDA, cornmeal, oatmeal, lima bean; CV8A and on V-8-juice agar (V8JA) at 30 C (Fig. 1).

Proliferating sporangia were produced by all five isolates (FIG. 2C). Sizes of sporangia of all isolate were similar, ranging from 42 to 83 X 29 to 48 µm (average 61.8 X 37.3 µm). These measurements are also comparable to published data of sizes of sporangia of *P.cryptogea, P. drechsleri* (15, 16, 17), *P. cajani* (1), and *P. drechsleri* var. *cajani* (TABLE II). The sporangial stalks within the same culture were either

narrowly tapered or widened somewhat at the base of the sporangium (FIGS. 2A, B).

Mating experiments with A^1 and A^2 mating types of *P. cinnamomi, P. cambivora, P. cryptogea,* and *P. drechsleri* indicated that all of our pigeon-pea isolates, as well as *P. drechsleri* var. *cajani,* were of the A^1 mating type. The greatest number of oogonia and oospores was found in matings with the A type of *P. cryptogea.* Bicellular antheridia were noted in some interspecific crosses with *P. cinnamomi* (TABLES III, IV). Variation in oogonium sizes was noted between the same interspecific crosses with the A- mating type of *P. cinnamomi* (Pc40) on the modified CV8A, and on carrot agar. Oospore sizes, however, showed little variation (TABLES III, IV, V, VI, and VII). A greater abundance of bicellular antheridia was observed on carrot-agar medium than on the

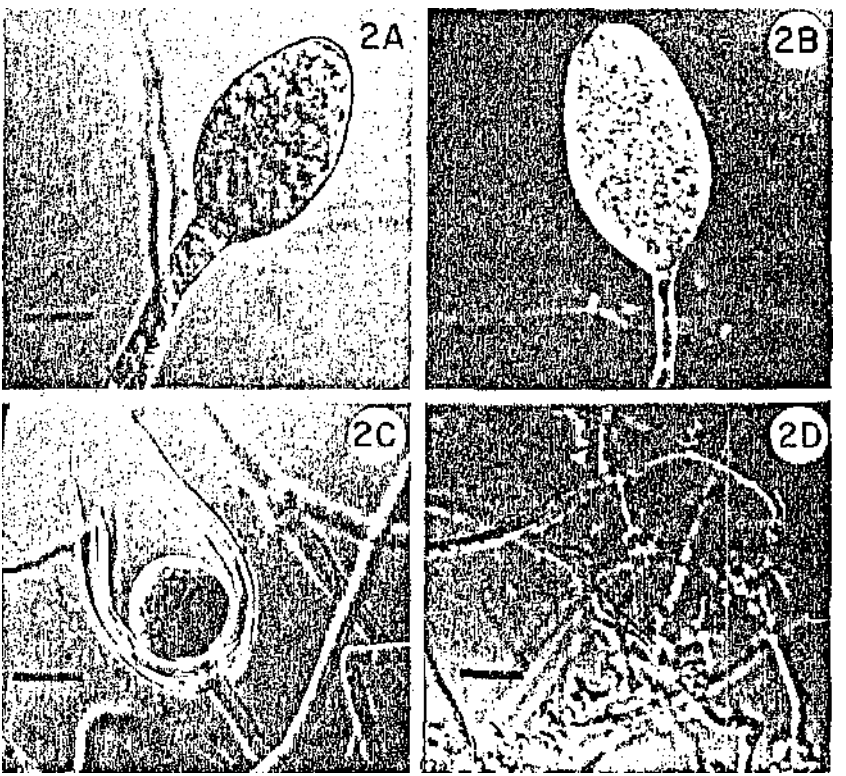

FIG. 2. A-C. Sporangia of pigeon-pea *Phytophthora* isolate (P2). Note differences in width of stalk within the same culture. Bar = 15 μm. D. Mycelium of pigeon-pea *Phytophthora* isolate at low temperatures (9-18 C). Bar = 20 μm.

TABLE III

FORMATION OF SEXUAL ORGANS IN CROSSES BETWEEN SEVERAL ISOLATES OF *Phytophthora* (p2-p6) FROM PIGEON PEA AND THE A^2 MATING TYPE OF *P. cinnamomi* (PC40) ON CARROT-AGAR MEDIUM (6)

Matings	Sex[a] organs	Oogonia (μm)	Antheridia (μm)	Oospores (μm)
P2 X Pc40	+ +	37-48 (43)[c]	17-37 (24) X 15-20 (17)**	34-44 (38)
P.3 X Pc40	+ + +	29-48 (40)	15-29 (18) X 12-21(16)*	25-44 (35)
P4 X Pc40	+	35-42 (39)	17-29 (22) X 12-21 (16)*	29-40 (34)
P5 X Pc40	0 --		—	—
P6 X Pc40	+ +	27-37 (32)	15-19 (16) X 15-19 (16)	23-31 (27)
Pdc[b] X Pc40	+ +	29-37 (32)	17-29 (21) X 15-19 (16)**	25-32 (28)

* = some bicellular antheridia present; ** = approximately 50% bicellular antheridia observed.

- Numbers of oogonia are indicated as: + = 1-10 oogonia; + + = 11-20 oogonia; and + + + = above 20 oogonia per 100 X microscopic field.

[b] Pdc = *P. drechleri* var, *cajani* from Pal et al. (8).

[c] Data in parentheses are the average of 50 measurements.

modified CV8A medium. Oogonia were not formed in cross P5 X Pc40 on carrot agar, but oospores were formed on the modified CV8A medium (TABLES III, IV). In interspecific crosses with the A^2 mating type

TABLE IV

FORMATION OF SEXUAL ORGANS IN CROSSES BETWEEN ISOLATES OF *Phytophthora* (P2-?6) FROM PIGEON PEA AND THE A^2 MATING TYPE OF *P.cinnamomi* (PC 1-10) ON MODIFIED V-8-JUICE MEDIUM (4)

Matinga	Sex organs	Oogonia (μm)	Antheridia (μm)	Oospores (μm)
P2 X Pc140	+ + +	35-46 (40)[a]	15-25 (19) X 15-21 (17)*	31-40 (35)
P3 X Pc140	+ + +	25-35 (31)	10-19 (15) X 10-21 (15)	21-31 (26)
P4 X Pc140	+ +	29-46 (34)	12-23 (17) X 12-19 (16)*	25-42 (31)
P5 X Pc140	+ +	27-35 (32)	12-19 (15) X 10-19 (15)	21-31 (27)
P6 X Pc140	+ +	33-42 (37)	15-25 (19) X 15-21 (18)*	29-37 (34)
Pde[b] X Pc140	+ + +	29-44 (37)	15-31 (19) X 12-19 (16)**	25-34 (31)

* = an occasional bicellular antheridium observed.

[a] Numbers of oogonia are indicated as follows: + + = 11—20 oogonia and + + + = more than 20 oogonia per 100 X microscopic field.

[b] Pdc = *P. drechsleri* var. *cajani* from Pal et al. (8)

Data in parentheses are the average of 50 measurements.

TABLE V

FORMATION OP SEXUAL ORGANS IN CROSSES BETWEEN ISOLATES OF *Phytophthora* (p2-p6) FROM PIGEON PEA AND THE A^2 MATING TYPE OF *P. cambivora* (p592) ON MODIFIED V-8-JUICE MEDIUM (4)

Matings	Sex[a] organs	Oogonia (μm)	Antheridia *(μm)*	Oospores *(urn)*
P2 X P592	0			
P3 x P592	+ + +	27-44 (35)[c]	12-21 (16) X 12-19 (16)	21-38 (30)
P4 X P592	+	33-42 (38)	17-40 (26) X 15-23 (19)	31-38 (34)
P5 X P592	+	33-42 (36)*	12-21 (16) X 12-19 (16)	27-35 (31)
P6 X P592	0	—	—	—
Pdc[b] X P592	+	37-40 (38)*	12-19 (16) X 12-17 (15)	31-33 (32)

* = Approximately 50% of the oogonia were with verrucose walls.
[a] Numbers of oogonia are indicated as follows: + == 1—10 oogonia; + + = 11-20 oogonia; and + + + = more than 20 oogonia per 100X microscopic field.
[b] Pdc = *P. drechsleri* var. *cajani* from Pal et al. (8).
[c] Data in parentheses are the average of 50 measurements.

of *P. cambivora* (PS92), and *P. drechsleri* (P1087), little variation was noted in oogonium and oospore sizes (TABLE V, VI). Aplerotic oospores were produced in crosses P3 X P1087 and P6 X P1087 (TABLE VI). Oogonia with an echinulate or verrucose outer wall were observed only in certain crosses with the A^2 mating type of *P. cambivora*

TABLE VI

FORMATION OK SEXUAL ORGANS IN CROSSES BETWEEN ISOLATES OF *Phytophthora* (P2~P6) FROM PIGEON PEA AND THE A^1 MATING TYPE OF *P. drechsleri* (P1087) ON MODIFIED V-8-JUICE MEDIUM (4)

Matings	Sex[a] organs	Oogonia	Autheridia (μm)	Oospores (μm)
P2 X P1087	+	29-40 (35)[c]	12-17 (15) X 12-17 (15)	27-35 (31)
P3 X P1087	+ +	24-35 (31)	12-21 (17) X 15-19 (16)	20-29 (25)*
P4 X P1087	+	27-40 (34)	10-17 (15) X 12-17 (14)	23-35 (39)
P5 X P1087	+ +	27-35 (30)	12-19 (15) X 12-19 (15)	21-29 (26)
P6 X P1087	+ +	29-37 (33)	12-19 (15) X 12-17 (15)	23-31 (27)*
Pdc[b] X P1087	+ + +	29-44 (35)	12-21 (15) X 12-15 (13)	23-35 (28)

* = oospores aplerotic.
[a] Numbers of oogonia are indicated as follows: + = 1-10 oogonia; + + = 11-20 oogonia; and + + + = more than 20 oogonia per 100 X microscopic field.
[b] Pdc = *P. drechsleri* var. *cajani* from Pal et al. (8).
[c] Data in parentheses are the average of 50 measurements.

TABLE VII

FORMATION OF SEXUAL ORGANS IN CROSSES BETWEEN ISOLATES OF *Phytophthora* (P2-P6) FROM PIGEON PEA AND AN A^2 MATING TYPE OF *P. cryptogea* (p1016) ON A MODIFIED V-8-JUICE AGAR MEDIUM (4)

Matings	Sex[a] organs	Oogonia (μm)	Antheridia (μm)	Oospores (μm)
P2 X P1016	+ + +	26-41 (34)[c]	10-17 (13) X 12-19 (15)	22-34 (28)
P3 X P1016	+ + +	29-41 (34)	12-19 (15) X 12-22 (17)	22-34 (27)
P4 X P1016	+ + +	31-41 (35)	12-17 (16) X 12-19 (16)	22-36 (27)
P5 X P1016	+ + +	31-38 (34)	12-19 (15) X 10-22 (16)	22-31 (26)
P6 X P1016	+ + +	26-36 (31)	12-17 (15) X 12-22 (17)	19-29 (23)
Pdc[b] X P1016	+ + +	29-38 (32)	12-19 (16) X 12-24 (17)	19-30 (23)

[a] Numbers of oogonia are indicated as follows: + + + = more than 20 oogonia per 100X microscopic field.
[b] Pdc = *P. drechsleri* var. *cajani* from Pal et al. (8).
[c] Data in parentheses are the average of 50 measurements.

(TABLE V). The frequency of echinulate oogonia varied in crosses with different pigeon-pea isolates; PS X *P. cambivora* (P592) produced a majority of echinulate oogonia, while P3 X *P. cambivora* had no echinulate oogonia although abundant oogonia were produced (TABLE V).

A few deeply pigmented oospores were observed in single cultures of isolates P2, P3, P4, P5, and P6 incubated on oatmeal agar at 30 C for 3 wk. This apparent homothallic capability was not observed at any other temperature on several media tested.

Terminal and intercalary hyphal swellings with fingerlike projections similar to those observed by Amin et al. (1), were noted in our isolates (FIG. 2D), but only at low temperatures (9-18 C). No chlamydospores were observed in any of the media tested or at other temperature regimes. Since none of the hyphal swellings were delimited by a septum, they were not considered to be chlamydospores.

Pathogenicity tests.—Pathogenicity tests using 20 plant species indicate that isolates P2, P3, P4, P5, and P6 were pathogenic to stems of pigeon pea *(Cajanus cajan)* and some species of *Atylosia,* a closely related wild species commonly found in India (TABLE VIII). The pigeon-pea cultivar ICP-7065 was resistant to isolate P2 and to *P. drechsleri* var. *cajani,* but cultivar HY-3C was susceptible to all isolates. This indicates the probability that races exist within the

collection of isolates from pigeon pea (TABLE IX). None of the *Phytophthora* isolates from pigeon pea were pathogenic to roots of pigeon-pea plants, although several attempts were made using both zoospore suspensions and mycelium as inoculum.

DISCUSSION

The symptoms of the *Phytophthora* blight disease on pigeon pea have been described in detail by Pal et al. (8) as a stem rot, by Williams et al. (18) as a stem blight, and by Kaiser and Melendez (6) as a stem canker. We prefer to use the term blight to describe the disease, since all aboveground parts of the plant are affected. The roots of diseased plants show no symptoms.

Isolates P2, P3, P4, P5, and P6 show similar sporangium morphology to that described by Waterhouse (16, 17) for the *P. cryptogea/*

TABLE VIII

PATHOGENICITY OF *Phytophthora* ISOLATES (P2-P4) FROM PIGEON PEA *(Cajanus cajan)* TO VARIOUS PLANT SPECIES

Plant species	*Phytophthora* isolates[a]		
	P2	P3	P4
Cajanus cajan (cv. HY-3C) (pigeon pea)	+	+	+
Cajanus cajan (ICP-7065) (pigeon pea)	–	+	+
Osteospermum sp. (African daisy)	—		
Medicago sativa L. cv. Moapa (alfalfa)	—	—	—
Persea indica (L.) K. Spreng (wild avocado)	—	—	—
Citrus sinensis (L.) Osbeck (orange)	—	—	—
Vigna sinensis L. (cowpea)	—	—	—
Cucumis sativus L. cv. Straight-8 (cucumber)	—	—	—
Solanum melagenum L. cv. Black beauty (eggplant)	—	—	—
Capsicum annuum L. (pepper)	—	—	—
Vinca minor L. (periwinkle)	–	—	—
Solanum tuberosum (L.) (potato)	—	—	—
Carthamus tintorius L. cv. N-10 (safflower)	—	—	—
Glycine max (L.) Merrill (soybean)	—	—	—
Helianthus annuus L. cv. Summer beauty (sunflower)	—	–	—
Lycopersicum esculentum L. cv. Pearson (tomato)	—	—	—
Crotalaria juncea L. (sunn-hemp)	—	—	—
Phaseolus vulgaris L. (french bean)	—	—	—
Phaseolus sp. (valor bean)	—	—	—
Pisum sativum L. (pea)	—	—	—
Cicer arietinum L. cv. White Spanish (chick pea)	—	—	—
Atylosia sericea Benth. ex Baker	—	—	—
A. platycarpa Benth.	—	—	—
A. volubis Gamble	+	+	+
A. scarabaeoides Benth.	+	+	+
A. lineata Wight & Arn.	+	+	+
A. cajanifolia Haines	+	+	+
A. albicans Benth.	+	+	+

[a] + = susceptible; — = resistant.

TABLE IX

REACTION OF *Cajanus cajan* (PIGEON PEA) CULTIVARS 7119 AND 7065 TO DIFFERENT *Phytophthora* SPECIES

Phytophthora isolates tested	Host	Pigeon-pea cultivars	
		7119	7065
P2	Pigeon pea	+	–
P3	Pigeon pea	+	+
P4	Pigeon pea	+	+
P5	Pigeon pea	+	+
P6	Pigeon pea	+	+
P. *drechsleri* var. *cajani* Pal, Grewel, & Sarbhoy	Pigeon pea	+	–
P. *caclorum* (Leb. & Cohn) Schr. (Blackwell's type) (P715)	Citrus	–	–
P. *colocasiae* Racib. (P356)	*Colacasia*	–	–
P. *cryptogea* Pethyb. & Laff. (P187, A^1)	Tomato	–	–
P. *cryptogea* (P637, A^2)	Unknown	–	–
P. *cryplogea* (P1016, A^2)	Bean	–	–
P. *capsici* Leonian type (P1091)	Pepper	–	–
P. *citricola* Sawada type (P716)	Orange	–	–
P. *citrophthora* (Sin. & Sm.) Leonian (P479)	Citrus	–-	–
P. *cinnamomi* Rands (Pc40, A^2)	Avocado	–	–
P. *cambivora* (Petri) Buisman (P592, A^2)	Noble fir	–	_
P. *drechsleri* (P8S2, A^1)	Safflower	–	–
P. *drechsleri* (P1076, A^1)	*Pinus radiata*	+	–
P. *drechsleri* type (P1087, A^2)	Potato	–	–
P. megasperma Drechs. f. sp. *medicaginis* Kuan & Erwin (P1057)	Alfalfa	–	–
P. megasperma f. sp. *glycinea* Kuan & Erwin (P406)	Soybean	–	–
P. megasperma—cv HTI (P238)	Alfalfa	–	–
P. megasperma—cv HTI (P240)	Alfalfa	–	–
P. parasitica Dastur (P991, A^2)	Citrus	–	–
P. parasitica (P1070)	Periwinkle	–	–
P. parasitica (P968)	Pigeon pea	+	+
P. palmivora (Butler) Butler (P550, A^1)	Cacao	–	–
P. vignae Purss (P606)	Cowpea	–	–

* High-temperature isolate.

P. drechsleri group. Although *P. cryptogea* and *P. drechsleri* are very similar in general morphology, these two species have been separated by Waterhouse (16, 17) based on the following characteristics: *P. cryptogea* has smaller sporangia (average size 37-40 X 23 µm, maximum 55 X 30 µ*m)* than *P. drechsleri* (average size 36-50 X 36-30 µm, maximum 70 X 40 µ*m)*. *Phytophthora cryptogea* produces sporangia sympodially and the sporangium has a conspicuous vacuole. Also, sporangia of *P. cryptogea* have a less variable shape than *P. drechsleri*. *Phytophthora drechsleri* sporangia have been described as broadly obpyriform to elongated obpyriform, sometimes asymmetrical and taper-

ing at the base (16, 17). Based on these criteria, our isolates resemble *P. drechsleri* more closely than *P. cryptogea.* Also, our isolates have a high temperature maximum (36 C) similar to that recorded for *P. drechsleri* (15, 16, 17).

A comparative study of Australian isolates of *P. cryptogea* and *P. drechsleri* by Bumbieris (3), indicated that the two species were physiologically and morphologically similar. Therefore, he suggested combining these two species as *P. cryptogea,* which has priority, being the older name. Chitzanidis and Kouyeas (5) also demonstrated the wide variation in sporangial sizes of several isolates of *P. cryptogea* when cultures were grown on different media. Sporangial sizes overlapped those recorded for *P. drechsleri.* Ashby (2) also noted the wide variation in sporangial sizes of *P. cryptogea* isolates. Our review of the literature on *P. drechsleri* indicates great variation in the size of sporangia, presence or absence of chlamydospores and hyphal swellings. Isolates of *P. drechsleri* have been reported as being homothallic (14, 15), or heterothallic (10, 11, 16, 17). Tucker's (15) original description of *P. drechsleri* recognized the close similarity between *P. drechsleri* and *P. cryptogea,* but distinguished between them on the basis of then-optimum temperature for growth—a higher optimum temperature (30-32.5 C) for the former. Recently, Shepherd and Pratt (12) studied several Australian isolates of *P. drechsleri* on the same medium used by Tucker (15), and found that 28 of their isolates had optima at 25 C and 24 isolates had optima at 30 C. Some of their isolates had a maximum temperature for growth similar to that described by Tucker (15), while others exhibited a lower temperature maximum. Bumbieris (3) reported that some isolates of *P. cryptogea* and *P. drechsleri* did not grow at *37* C, but both species had optima between 25-30 C.

The formation of oogonia has also been used as a criterion for separating *P. cryptogea* and *P. drechsleri.* Waterhouse (16) found that *P. drechsleri* did not form oogonia when crossed with *P. cinnamomi.* Our studies indicate that oogonia formed readily in crosses with *P. cinnamomi,* but the number produced varied with the isolate of *P. drechsleri* used. Shepherd (11) recently reported a detailed study of inter- and intraspecific mating behavior of several *Phytophthora* species. He found that A^1 isolates of *P. drechsleri* readily formed oogonia when mated with *P. cinnamomi,* but not when crossed with the A^2 mating type of *P. drechsleri* or *P. cryptogea.* Crosses with *P. cryptogea* exhibited similar mating behavior, leading him to suggest that these two species are conspecific. Our mating tests agree in general with Shepherd's findings (11). However, contrary to his

observations, our *P. drechsleri* X *P. cryptogea* crosses produced abundant oogonia, These conflicting results tend to lend support to our contention that although the proposal to merge *P. drechsleri* with *P. cryptogea* (3) deserves consideration, we feel that not enough data are presently available unequivocally to merit this change. The isolates of *P. drechsleri* and *P. cryptogea* thus far examined are limited to certain geographic areas and to a few hosts. A much greater number of isolates of these species from several different hosts should be critically compared. Until such data are available, we prefer to follow Waterhouse (16, 17) in retaining *P. drechsleri* as a separate species.

We cannot state unequivocally that the isolates described as *P. cajani* by Amin et al. (1) are the same as our isolates since cultures of this fungus have apparently been lost. However, the morphology and size of sporangia were similar to our isolates. Homothallism as cited by Amin et al. (1) does not differentiate *P. cajani* from *P. drechsleri* since homothallic isolates of *P. drechsleri,* have previously been described (14, 15). Our studies showed that the isolates P2, P3, P4, P5, and P6 were A^1 mating type when crossed with A^2 isolates of other species of *Phytophthora,* but at 30 C on OMA these isolates were homothallic.

Our data support the classification of the isolates P2, P3, P4, PS, and P6 as *P. drechsleri* since they closely resemble, in most details, the characteristics described by Tucker (15) for this species. Although the formae speciales concept has not previously been used to classify host-specific isolates of *Phytophthora drechsleri,* it appears to be appropriate here. The data in TABLES VIII and IX indicate that the isolates from pigeon pea are host specific. Therefore, the use of *P. drechsleri* f. sp. *cajani* is presented as the name for the *Phytophthora* causing blight of pigeon pea. The designation is in conformity with the International Rules of Botanical Nomenclature, Article 4 (13). The term "variety" (e.g., var. *cajani)* was used by Pal et al. (8), but variety should be based on morphological differences and not on host specificity (13). The use of formae speciales was recently proposed by Kuan and Erwin (7) in designating host specific isolates of *P. megasperma.*

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