

## CLÁSSICOS DA CITRICULTURA BRASILEIRA

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### APRESENTAÇÃO

A Gomose e podridão de raiz causada por *Phytophthora* estão, economicamente, entre as mais importantes doenças em citros. *Phytophthora nicotianae* (*Phytophthora parasitica*) e *Phytophthora citrophthora* têm causado graves danos em citros nos viveiros e nos pomares em todo o mundo. No Brasil, *P. parasitica* é a espécie predominante associada com a doença, encontrada em mais de 95% dos pomares e viveiros.

Uma forma de contaminação nos pomares é a disseminação da doença via muda contaminada. Sem dúvida, com a implantação do sistema de produção de mudas em ambiente protegido no estado de São Paulo, em 2003, a comercialização de muda sadia passou a ser uma importante forma de controle da doença no campo. Entretanto a utilização, ainda, em grande escala de porta enxertos suscetíveis e a presença endêmica do inóculo nas principais áreas produtoras de citros faz com que a doença continue sendo um problema importante nos pomares paulistas e brasileiros.

Nos clássicos da citricultura brasileira desta edição é apresentado um dos primeiros trabalhos de isolamento, ocorrência, patogenicidade vs temperatura destas espécies de *Phytophthora* no Brasil e outros países da América do Sul, publicado nos Arquivos do Instituto Biológico, referência nacional em estudos desta natureza na época.

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# Occurrence, pathogenicity, and temperature relations of phytophthora species on citrus in Brazil and other south american countries<sup>1</sup>

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## SUMMARY AND DISCUSSION

Five species of Phytophthora up to the present time have been isolated and identified from Citrus in South America, namely, *Phytophthora citrophthora*, *P. parasitica*, *P. cactorum*, *P. palmivora*, and *P. cinnamomi*. *P. citrophthora* has been isolated in three localities in Brazil and three localities in Argentina; *P. parasitica* in seven localities in Brazil, two in Argentina, and one in Paraguay; *P. cactorum* in two places in Brazil and one in Argentina; *P. palmivora* in one locality in Argentina, one in Uruguay, and one in Dutch Guiana; and *P. cinnamomi* has been isolated in one locality in Brazil. As far as known, *P. cinnamomi* has not been isolated previously from Citrus in any country. It is also the only Phytophthora species that has been found producing comparatively extensive lesions on sour orange. Assuming that *P. citricola* is the same species as *P. cactorum*, this species under name of *P. citricola* has been isolated before only in Japan and South Africa.

Inoculations into citrus trees at São Paulo with three of these species showed, in spite of variations between individual trees of the same variety, differences that were probably related to differences in species of both the parasites and the hosts. The results with *Phytophthora citrophthora* were comparable to those obtained in previous experiments in California in which the lemon was the most susceptible with orange and grapefruit less susceptible and tangerine still less.

Inoculation of a small number of fruits kept at temperatures from 25° to 30°C gave the following results: Infection of all fruits with *Phytophthora citrophthora*, 2 to 3 fruits out of 7 with each of 3 isolates of *P. parasitica*, and only 1 fruit out of 7 with *P. cactorum*. *P. cactorum*, although present in California on walnuts (*Junglans regia*), has not been found in the field on citrus fruits or bark except as *P. citricola* in Japan and South Africa and does not infect such fruits readily under artificial inoculations.

Four of the species tested for growth in relation to temperature showed certain marked difference as to range and as to optimum temperature. With the temperatures used *Phytophthora citrophthora* showed a much wider range of temperature for growth than did either *P. cactorum* or *P. cinnamomi*. The results with both *P. citrophthora* and *P. parasitica* agree well in general with the growth temperature relations previously tested in California for other isolated of these species.

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<sup>1</sup> This investigation is part of a collaboration made possible by an invitation from Dr. H. da Rocha Lima of the Instituto Biológico to the first author to spend a half year in Brazil at the above institution. Appreciation is here expressed for the excellent facilities furnished by this institution through its Director and Staff. Other papers covering other phases of the investigations and observations of this period of collaboration so far published may be referred to in the Literature Cited under numbers 9, 10, 11, 12, 13, 14, 15, 16, and 17.

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<sup>4</sup> Culture sent by G. Stahel. Letter to H. S. Fawcett of August 4, 1933. Identified by Dr. C. M. Tucker, University of Missouri.

<sup>5</sup> Cultures sent by H. A. Speroni. Letters to H. S. Fawcett of June 7, 1937 and November 25, 1939.

## SUMÁRIO

### Ocorrência, patogenicidade e desenvolvimento de acordo com a temperatura, das espécies de *Phytophthora parasitas dos citrus no Brasil e outros países sul-americanos*

Até a presente data foram isoladas e identificadas na América do Sul cinco espécies de *Phytophthora*, *Phytophthora citrophthora*, *P. parasitica*, *P. cactorum*, *P. palmivora*, e *P. cinnamomi*. *P. citrophthora* foi isolada de espécimens provenientes de 3 localidades do Brasil e 3 da Argentina; *P. parasitica* de 7 localidades do Brasil, 2 da Argentina e uma no Paraguai; *P. cactorum* de duas do Brasil e uma da Argentina; *P. palmivora* de uma localidade da Argentina, uma do Uruguai e uma da Guiana Holandesa e *P. cinnamomi* de uma do Brasil. Ao que se saiba é essa a primeira vez que *P. cinnamomi* foi isolada de Citrus. É igualmente a única espécie de *Phytophthora* que foi encontrada até hoje produzindo lesões relativamente extensas em laranja azeda. Admitindo-se que *P. citricola* não passa da mesma espécie de *P. cactorum*, esta última, sobre o primeiro nome, foi isolada anteriormente, de Citrus, somente no Japão e na África do Sul.

As inoculações feitas em São Paulo com 3 dessas espécies mostraram apesar de algumas variações observadas entre árvores da mesma variedade, diferenças que são provavelmente relacionadas com diferenças nas diversas espécies do parasita e do hospede. Os resultados obtidos com *Phytophthora citrophthora* são comparáveis aos obtidos em experiências anteriores, na Califórnia, onde se verificou que o limoeiro era a espécie mais suscetível, sendo menos suscetível que ele, na ordem decrescente a laranja doce, pomelo e a tangerineira.

Inoculações efetuadas em pequeno número de frutas conservadas à temperatura de 25 a 30°C deram os seguintes resultados: infecção em todas as frutas com *P. citrophthora*, em 2 a 3 frutas sobre 7 com cada um dos 3 isolamentos de *P. parasitica* e somente uma fruta sobre 7 com *P. cactorum*. *P. cactorum*, bem que presente na Califórnia na nogueira europeia, não foi encontrada, em condições naturais, em frutas, ou na casca do tronco ou ramos, de Citrus. No Japão e na África do Sul, entretanto, esta espécie, foi assinalada sobre Citrus sob o nome de *P. citricola*. Ela infecta dificilmente as frutas nas inoculações artificiais.

O crescimento de 4 dessas espécies foi estudado em relação à temperatura, verificando-se algumas notáveis diferenças entre as mesmas, tanto na extensão da faixa de temperaturas em que crescem, como na temperatura ótima de crescimento. *P. citrophthora* mostra maior desenvolvimento a 24°C, *P. cactorum* à 28°C, *P. cinnamomi* e *P. parasitica* à 31°C. *P. parasitica* mostrou uma faixa de temperatura muito mais extensa que *P. cactorum* e *P. cinnamomi*. Os resultados obtidos com *P. citrophthora* e *P. parasitica* concordam em geral com os anteriores obtidos na Califórnia, com outros isolamentos dessas mesmas espécies.

## INTRODUCTION

This paper deals for the most part with the occurrence, pathogenicity, and temperature relations of species of *Phytophthora* isolated in Brazil from November 1936 to March 1937. The isolations made in Argentina, Paraguay, and Uruguay from April 12 to May 10, 1937, are also included. So far as known, the other isolations and accurate identifications of *Phytophthora* from South American countries include only *Phytophthora parasitica* Dastur by G. L. Fawcett

(6) in 1922, from foot rot of sweet orange (*Citrus sinensis* Osb.) in Tucuman, Argentina, and by A. S. Müller (21) in 1933 in Viçosa, Brazil, also from foot rot, and *P. palmivora* Butler, by G. Stahel (4) from citrus fruit in Surinam (Dutch Guiana). Since then *P. parasitica* has also been isolated from foot rot of "Lima da Persia", a sweet lime (*Citrus aurantifolia* Sw.) and *P. citrophthora* from fruit and from bark of sweet orange at Bella Vista, Argentina (5).

The other references in literature to *Phytophthora* on Citrus in South America as far as can be judged

from the literature have been those of isolations not sufficiently identified or observations of lesions of brown rot gummosis or foot rot from which it has been assumed that *Phytophthora* was the causal agent. The references we have been able to find to *Phytophthoras* or foot rot-like lesions which were assumed to be caused by *Phytophthora* are Avena-Sacca (2) in 1912, Bitancourt (3, 4) in 1933 and 1936 in Brazil, Nolla (22) 1930 in Colombia, Acosta (1) 1931 in Uruguay, and Blanchard (5) 1930 in Argentina. The world distribution of *Phytophthoras* up to 1933 is given by Tucker (23).

### ISOLATION OF PHYTOPHTHORA

The isolations from brown-rot gummosis or foot rot lesions were made for the most part from excised pieces of bark containing both sound and diseased tissues. Small bits were cut out with a sterile scalpel from the indefinite margin of active advancing lesions after flaming the inner surface of the bark and scraping it lightly with a scalpel.

These bits were dropped either on the surface of slanted tubes or on petri dishes of solidified nutrient media. Glucose maize or glucose potato agar was used. During trips many of the isolations were made in hotels and private homes using a small alcohol burner, scalpel and tweezers and planting the material directly on agar slants in test tubes measuring 90 by 12 millimeters. A convenient method in difficult cases has recently been reported by Klotz and Fawcett (20). Isolations from infected fruits were made most successfully by dropping whole seeds or bits of the core after flaming the surface of the fruit and cutting into the center.

The isolations made in the present investigation are listed below (<sup>1</sup>): the first number is that used by the present authors. Numbers in parenthesis are Citrus Experiment Station numbers. Some of these isolations have previously been referred to without definite identifications of species in reports of citrus diseases by the authors (9, 10, 11, 12, 13, 14, 15, 16, and 18).

### *Phytophthora citrophthora* (Sm. & Sm.) Leon.

758 (2012) from a fruit of grapefruit (*C. grandis* Osb.) lying on the soil at Lavras, Minas Gerais, Brazil, December 4, 1936.

823 from a sweet orange fruit (*C. sinensis* Osb.) on the soil at São Paulo, Brazil, February 1, 1937.

864 (2013) from Lima da Persia (sweet lime) fruit (*Citrus aurantifolia* Sw.) at São Paulo, Brazil, February 18, 1937.

85 (2005) from sour orange fruit (*C. aurantium* L.) on the soil at the Missions Ruins of San Ignacio, Misiones, Argentina, April 24, 1937.

157 from foot rot on 40-years-old sweet orange tree at Tucuman, Argentina, May 5, 1937.

### *Phytophthora cactorum* DeBary

767 from lemon fruit (*C. limonia* Osb.) on soil at São Paulo, Brazil, December 15, 1936.

778b from orange fruit on soil at São Paulo, Brazil, December 17, 1936.

123 (2006) from lemon fruit, Concordia, Argentina, April 27, 1937.

### *Phytophthora parasitica* Dastur

754 from foot rot on sweet orange tree, Campo Grande near Rio de Janeiro, Brazil, November 22, 1936.

784 from foot rot on sweet orange tree, Sorocaba, São Paulo, Brazil, January 6, 1937.

787b from lemon fruit on the soil at Sorocaba, São Paulo, Brazil, January 6, 1937.

802 from lemon fruit on soil at Piracicaba, São Paulo, Brazil, January 20, 1937.

833 from lemon fruit on soil at Piracicaba, São Paulo, Brazil, February 10, 1937.

834 (2011) from foot rot on sweet orange at São Paulo, Brazil, February 10, 1937.

867 (2007) from foot rot lemon tree, Coruputuba, São Paulo, Brazil, February 24, 1937.

<sup>1</sup> Dr. S. F. Ashby of the Imperial Bureau of Mycology, Kew, England, kindly made the identification of all these isolates.

913 (2010) from orange fruits on soil, Salvador, Bahia, Brazil, March 18, 1937.

26 (2008) from lemon fruit, Asuncion, Paraguay, April 18, 1937

### ***Phytophthora palmivora* Butler**

94 (2003) from foot rot on sweet orange at Santa Inez, Misiones, Argentina, April 24, 1937.

138 (2004) from foot rot on tangerine orange, (*C. nobilis* var. *deliciosa* Sw.) Salto, Uruguay, April 28, 1937.

### ***Phytophthora cinnamomi* Rands**

866 (2009) from foot rot on young sour orange tree, Guaratinguetá, São Paulo, Brazil, February 24, 1937.

## **INOCULATIONS ON TRUNKS OF CITRUS TREES**

Inoculations were made on the bark of several species of Citrus by three of the species of *Phytophthora* isolated from Citrus in Brazil, *Phytophthora citrophthora* (culture 758), *P. cactorum* (culture 767), and *P. parasitica* (cultures 784 and 787). The inoculations were made, as in previous experiments in California by Klotz and Fawcett (19) in 1930, by inserting uniform disks of mycelium grown on a nutrient media into wounds in the bark made by small cork borers, replacing the disks of bark made by the cork borer, and covering the wound with adhesive tape. These were made on January 28, 1937, and the measurements for table 1 were made for the lemon trees on February 17, 20 days later, and for the other trees on March 1, 32 days later, when the lesions were cut out. With the exception of those on "Lima da Persia" the lesion made by all three species tended to be larger on lemon than on the other hosts, there being less difference with *P. cactorum* and *P. parasitica* than with *P. citrophthora*. It should be noted that *P. cactorum* produced no lesions on "limão Galego" (sour lime: *C. aurantifolia* Sw.), while the other two fungi produced lesions of same general size as on grapefruit in each case. These lesions were typical of those of brown rot gummosis. As is apparent in the table, considerable

variable variation occurred in the size of the resultant lesions on certain individual trees of the same varieties and between the two isolations of *P. parasitica*. In a general way, however, the comparative results for *P. citrophthora* are in agreement with those of previous inoculations for this species in California (19), the lemon showing the largest lesions, the grapefruit (*C. grandis* Osb.) and Valencia orange (*C. sinensis* Osb.) averaging less, and the tangerine averaging still much less. The "Lima da Persia" (sweet lime: *C. aurantifolia* Sw.) showed a large lesion next in size to the lemon and both the "Limão Galego" and "Limão Cravo" (Rangpur lime: *C. aurantifolia* Sw.) had lesions comparable to those of most of the oranges.

The inoculation with *Phytophthora cactorum* showed somewhat comparable results except that most of the lesion were smaller. The lesion made by *P. cactorum* on Lima da Persia (Plate 34, V) was large as the average of the lemons (Plate 32, B and F).

In inoculations made with *Phytophthora parasitica* there appear smaller differences between those on lemons (Plate 32, C, D, G, and H) and those on oranges (Plate 33, O and P) than in case of the other two fungi.

On tangerines and "Limão cravo" the lesions are of about the same order as for those of the other two fungous inoculations. The largest lesion made by any of the three fungi was that on "Lima da Persia" (Plate 34) by *Phytophthora parasitica* (Plate 34, W) and measures 180 mm long and 45mm wide. The average of all the lemon lesions for *P. citrophthora* in only 121 mm long and 22 mm wide. The two isolates de *P. parasitica* showed differences in their effect on "Laranja Cravo" and "Pera orange", with small lesions or none for culture 784 and fair sized lesions for 787. Because of the variability in this table it is unsafe to draw too definite a conclusion. More extensive tests would be necessary. It may be said, however, that in general the results from *P. citrophthora* are in line with those obtained in previous tests with this species (19).

## **INOCULATIONS OF FRUITS**

On February 26, 1937, at São Paulo, inoculation experiments were made on fruits without injuries in the following manner: by the method of Fawcett and Klotz (17) sporangia which had been induced to form

**Table 1.** Measurements in millimeter of the lesions produced in 20 days (lemon trees) and 32 days (other trees) by inoculation of the bark of the trunk of citrus trees with culture of *Phytophthora* species (Plates 32 to 34). Where no number is mentioned, inoculations were not made

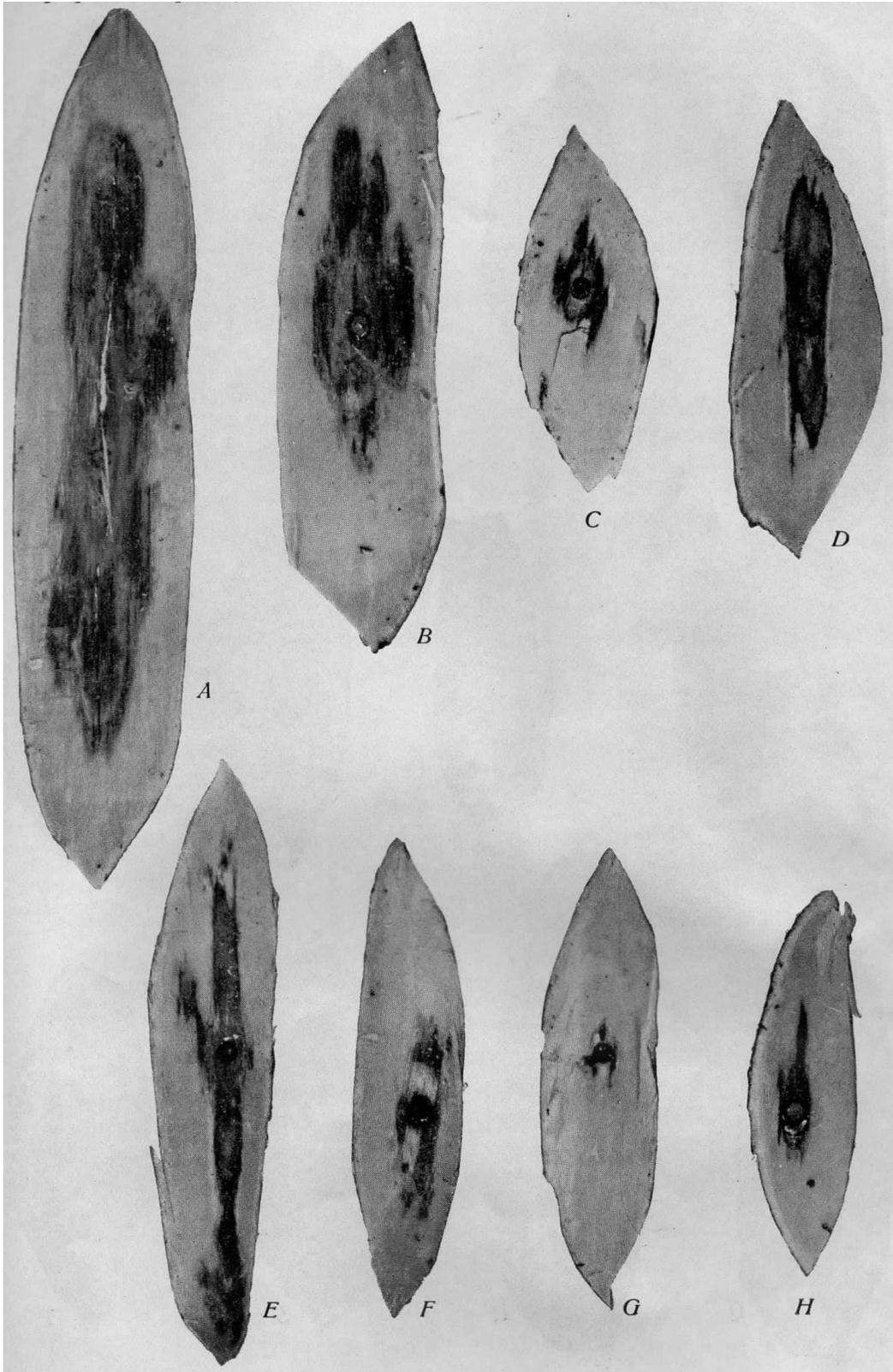
Variety	Tree n.º	<i>P. citrophthora</i> culture 758		<i>P. cactorum</i> culture 767		<i>P. parasitica</i> culture 784		<i>P. parasitica</i> culture 787	
		L*	W*	L*	W*	L*	W*	L*	W*
Limão Cravo (Rangpur Lime)	–	32	7	25	6	22	6	12	4
Limão Galego	35	45	8	0	0	16	8	30	9
Lima da Persia (Sweet Lima)	46	110	25	82	20	180	45	9	6
Tangerina do Rio	154	27	10	13	7	15	6	15	7
	153	7	6	12	6	10	6	18	7
Limão Cravo	163	48	10	42	9	0	0	25	7
	162	45	9	35	8	-	-	-	-
	161	-	-	-	-	9	6	20	7
Laranja Pera	136	20	6	18	5	-	-	-	-
	135	40	8	6	5	6	5	18	7
Valencia Orange	83	95	14	45	11	-	-	-	-
	82	30	12	85	11	-	-	-	-
Navel (Bahia) Orange (Washington)	12	-	-	-	-	15	6	75	8
	11	20	10	21	8	-	-	-	-
Marsh Grapfruit	22	-	-	-	-	7	8	32	20
	16	56	15	16	8	-	-	-	-
	15	54	18	25	12	32	19	25	12
Eureka Lemon	55	105	15	45	12	11	6	35	8
Villa Franca Lemon	72	147	15	48	11	35	8	60	10
	66	131	22	72	25	30	14	60	10
Sicilian Lemon	76	162	54	101	30	-	-	-	-
	75	137	16	85	7	20	10	75	16
	74	45	10	78	10	-	-	-	-

L\* length. W\* width

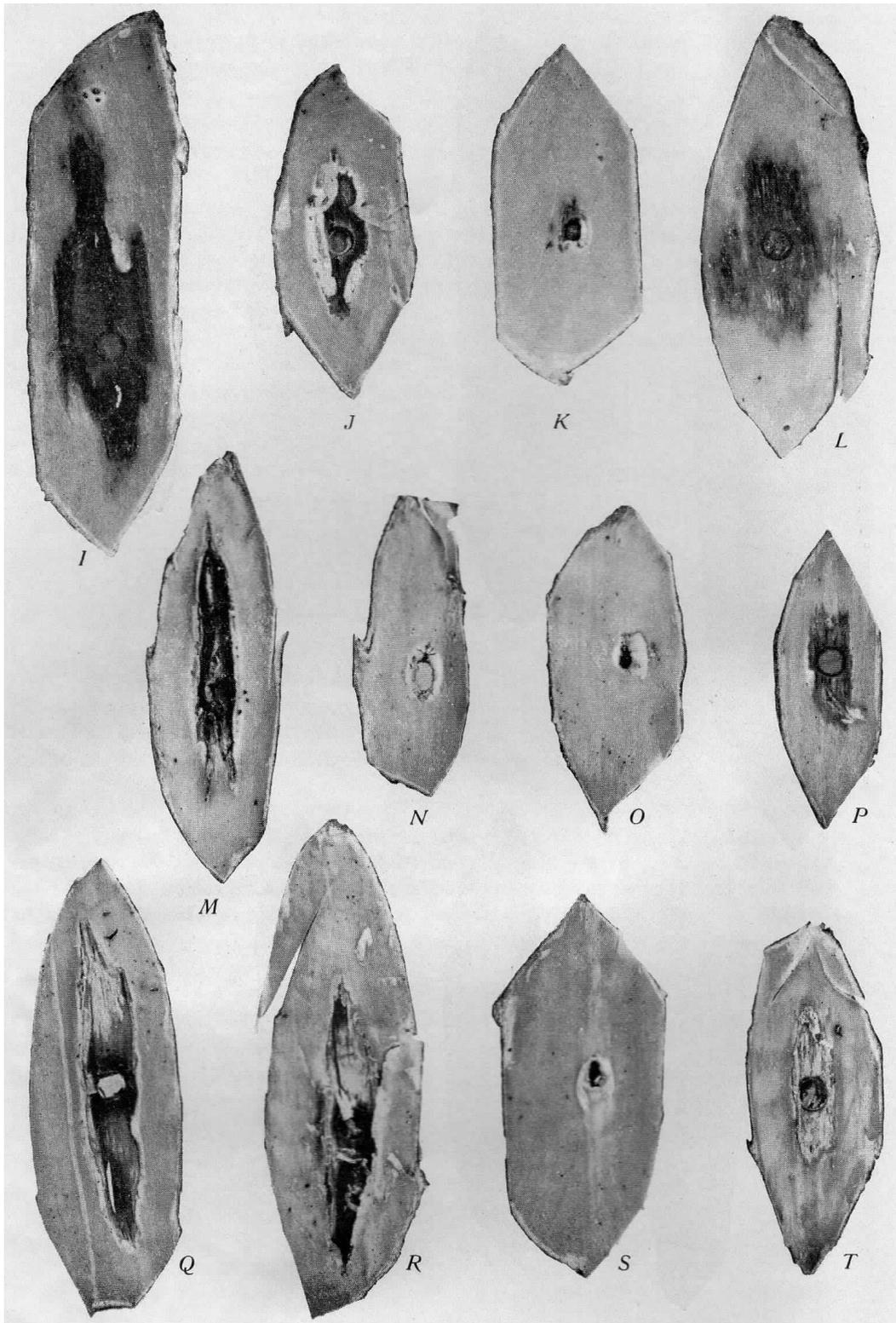
in a shallow layer of water by transferring mycelium from a culture in dilute prune juice were subjected first to 30°C for 5 minutes and then dropped quickly to 15°C. In all the dishes except that of *Phytophthora cactorum* swarm spores were seen in 15 minutes to one hour. These suspensions were then diluted with water at 15° to 18°C and citrus fruits were then immersed in the diluted suspensions. In each suspension 5 to 6 lemons, 3 oranges, and 1 grapefruit were immersed, some for 5 minutes and some for 20

hours. These were left in a moist atmosphere of the laboratory probably at about 25° to 30 °C. The results were as follows:

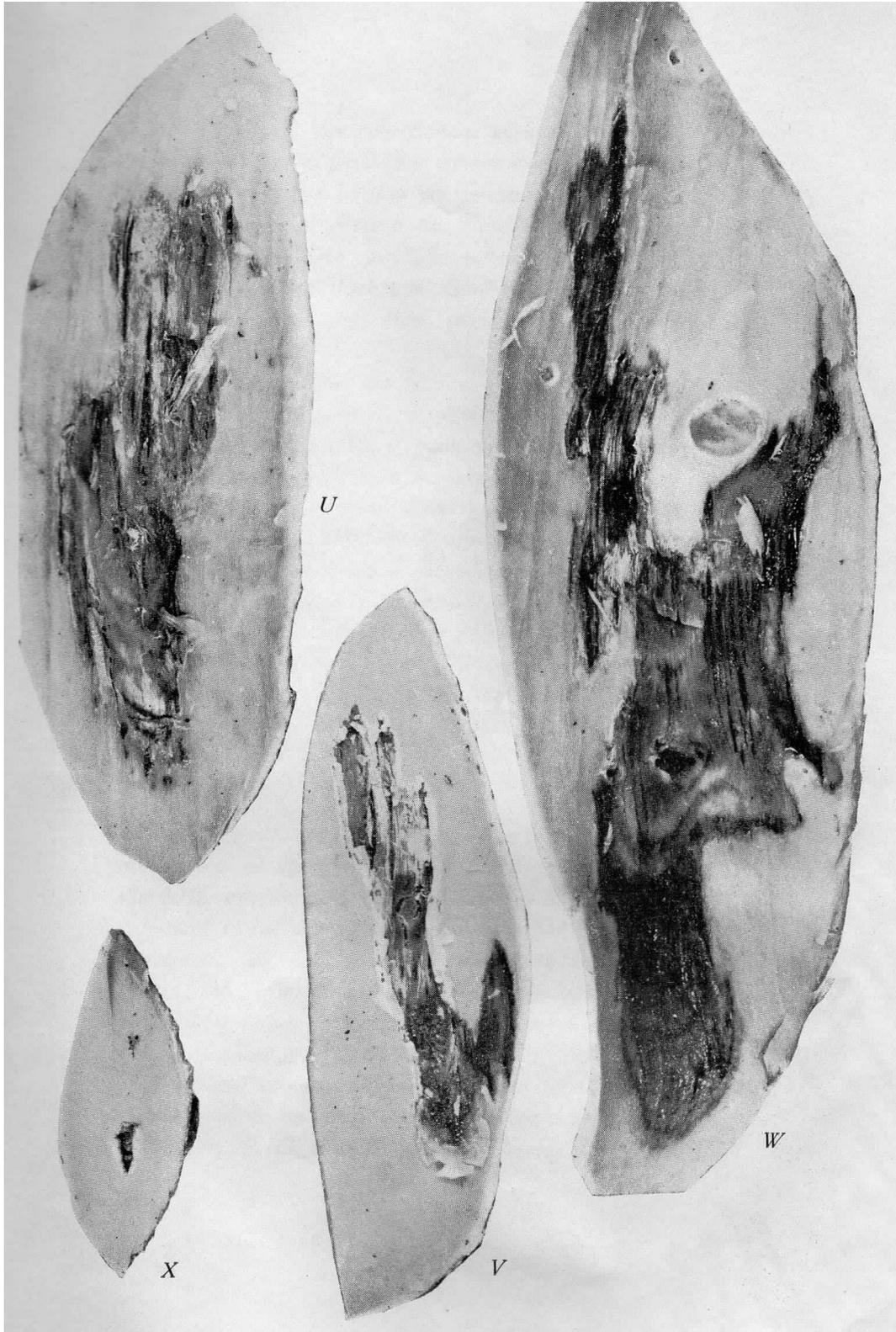
Under the conditions of the experiment *Phytophthora citrophthora* rotted all the fruits while the others the caused rotting of only 1 to 3 fruits each. The characteristic odor of the decay was weaker and less well defined in fruits inoculated with *P. parasitica* and *P. cactorum* than in those with *P. citrophthora*.



**Plate 32.** Excised bark of *Citrus limonia*. Obs. (Villafranca lemon, A-D and Eureka lemon, E-H) showing lesions at cambium side after 20 days from inoculations with *Phytophthora citrophthora* (A and E), *P. cactorum* (B and F), and two different isolates of *P. parasitica* (C and G, D and H) x 7/10.



**Plate 33.** Excised bark of Marsh Seedless Grapefruit (*Citrus grandis*, I-L), Sweet orange var. Pera (*Citrus sinensis*, M-P) and "Laranja Cravo" (*Citrus nobilis* var., Q-T) showing lesions at cambium side after 32 days from inoculations with *Phytophthora citrophthora* (I, M, and Q), *P. cactorum* (J, N and R) and two different isolates of *P. parasitica* (K, O and S, L, P and T) x 1.



**Plate 34.** Excised Bark of "Lima da Persia" (*Citrus aurantifolia*) showing lesions at cambium side after 32 days from inoculation with *Phytophthora citrophthora* (U), *P. cactorum* (V), and two different isolates of *P. parasitica* (W and X) x 4/5.

**Table 2.** Infection of citrus fruits by swarm spores of species of *Phytophthora*

Culture n.º	Organism	Reading made after	Fruits infected and results
758	<i>P. citrophthora</i>	7 days	5 min. exposure : 2 lemons, 1 orange. 20 hr. exposure: 3 lemons, 2 oranges and the grapefruit (2 of oranges entirely involved)
		10 days	All fruits (6 lemons, 3 oranges and the grapefruit) affected with characteristic rot and odor
767	<i>P. cactorum</i>	7 days	No effect on any fruits
		10 days	1 lemon fruit only affected
784	<i>P. parasitica</i>	7 days	1 lemon only
		10 days	1 lemon and the grapefruit
787	<i>P. parasitica</i>	7 days	1 lemon and the grapefruit
		10 days	1 lemon, 1 orange, and the grapefruit
754	<i>P. parasitica</i>	7 days	20 hr. exposure : 1 lemon only
		10 days	5 min. exposure : 1 orange
			20 hr. exposure : 1 lemon, 1 orange

### GROWTH-TEMPERATURE RELATIONS

For the temperature tests, circular disks of mycelium were placed on the center of petri dishes of maize agar, which were then placed in seven different temperature chambers at 5°, 10.5°, 17.5°, 24°, 28°, 31°, and 35° C, respectively. Two dishes of each different isolation were placed in the chambers at 10.5°, 17.5°, 24°, 28°, and 31°, and one each in the chambers 5° and 35°. The outline margin of the disk of mycelial growth was traced on transparent cellophane paper at various intervals<sup>(1)</sup> and the diameters of these tracings were later measured for table 3. None of the cultures grew at 5° C., which is therefore omitted from the table. The measurements were made at the 10.5° C. chamber only at 7 and 9 days. Two of the cultures, *Phytophthora cinnamomi* (866) and one of the *P. parasitica* (784), failed to show any growth at 10.5° during the period of observation.

As will be noted in table 3, *Phytophthora citrophthora* made greatest growth at 24°C and next at

28°C. This would indicate that the optimum temperature under the conditions of this experiment was somewhere between 24° and 28°C. For *P. citrophthora* this was possibly about 26°C as was the case in previous California experiments by the first author (7, 8) with another isolation. *P. cactorum* (767) made the greatest growth at 28°C but only slightly more than that at 24°C. Both grew slowly at 10.5° but failed to grow at 5° or 35°C.

The same relationship was shown by tests made by Vicent A. Wagner<sup>(2)</sup> with a transfer of the same fungus a year or more later. *P. cactorum* failed to grow at 31°C. *P. cinnamomi* (866) failed to grow at 5°C, 10.5°C, or at 35°C. It showed the largest growth at 31°C. The close approach of the growth figures at 28°C and at 31°C indicates that the real optimum under the conditions was probably between these two temperatures. In another test by Wagner the same relationships were evident. The maximum temperature for growth is probably very near 35° since Wagner<sup>(2)</sup> got a fair growth with the same isolate at 34° but none at 37°C.

<sup>1</sup> We are indebted to Euclides Ract for careful tracing of these cultures.

<sup>2</sup> Letter of September 15, 1939.

**Table 3.** Measurements in mm of diameters of mycelial disks of growth at different temperatures. Two petri dishes (a and b) and average (av) and average (av)

	Days	10.5°C			17.5°C			24°C			28°C			31°C			35°C		
		a	b	av	a	b	av	a	b	av	a	b	av	a	b	av	a	b	av
758	3	-	-	-	22	21	21.5	32	-	32	30	25	27.5	25	24.5	25	0	0	0
<i>Phytophthora</i>	5	-	-	-	40	32	36	48	-	48	38	46	41	38	35	36.5	0	0	0
<i>ciithophthora</i>	7	26.5	25.5	26	51	40	45.5	60	-	60	50	56	53	47.5	53	50	0	0	0
	9	29	28.5	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
767	3	-	-	-	26.5	26.5	26.5	42.5	34.5	38	42.5	40.5	41	0	0	0	0	0	0
<i>P. cactorum</i>	5	-	-	-	49	50	49.5	63.5	70	67	73.5	75	74	0	0	0	0	0	0
	7	19	19	19	71	74	72.5	83.5	86.5	85	85.5	87	86	0	0	0	0	0	0
	9	29	28.5	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
866	3	-	-	-	18	17.2	18	34	35	34.5	44.5	40.5	42	45.5	45	45	0	0	0
<i>P. cinnamomi</i>	5	-	-	-	33	34.5	34	52	58	55	71.5	65	68	72	76.5	74	0	0	0
	7	0	0	0	47	49	48	74	76	75	88	89	85.5	86	90	88	0	0	0
	9	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
784	3	-	-	-	18.5	18.5	18.5	16	18	17	22	28	25	29	32	30.5	15.5	-	15.5
<i>P. parasitica</i>	5	-	-	-	28.5	28.5	28.5	33	37	35	44	50	47	50	52	51	28.5	-	28.5
	7	0	0	0	35	36.5	36	50	52	51	60	70	65	71	72	71.5	36.5	-	36.5
	9	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
867	3	-	-	-	17	21	19	23	20	21.5	26	23.5	25	30	26.5	28	23	-	23
<i>P. parasitica</i>	5	-	-	-	22	31	26.5	35.5	32	34	42	37.5	40	42.5	40	41	31.5	-	31.5
	7	3	9	6	30	38	34	47.5	45	46	52.5	50	51	57	54	55.5	39.5	-	39.5
	9	10	14	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
833	3	-	-	-	20	21	20.5	23	23	23	28.5	27.5	28	25.5	34.5	30	25.5	-	25.5
<i>P. parasitica</i>	5	-	-	-	29	29	29	40	39	39.5	46	47	46.5	53	62	58	42.5	-	42.5
	7	6.5	9.5	8	34	35	34.5	60	60	60	75	75	75	73	80.5	77	61	-	61
	9	8.5	14	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A dash (-) indicates that no observations were made

A zero (0) indicates that observations were made but no growth was observed.

The results for the three *Phytophthora parasitica* isolations show the greatest growth at the temperature of 31°C. This optimum temperature and the wider range indicated is also in agreement with previous temperature experiments by the first author (7, 8) with this species. *P. parasitica* is the only one of the four species that grew at 35°C, at which temperature all three isolations made a considerable advance. Although the three isolations showed differences in the rates of growth among themselves, their relative responses to temperature were similar except that culture 784 failed to grow at 10.5°C at which the other two made a feeble growth after 7 and 9 days. Another test by Wagner (2) showed a relationship with culture 834 similar to that for 784, with no growth at 10°C but with a feeble growth at 13° and at 37°.

A test with *Phytophthora palmivora* (culture 94) from Argentina by Wagner showed a similar range to 834 with no growth at 10°C but a diameter growth of 7 mm at 13°, 17 mm at 16°, 34 mm at 19°, 44 mm at 22°, 50 mm at 25°, 47 mm at both 28° and 31°, 34mm at 34°, and 8 mm at 37°C.

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