

Keys to the Species of *Phytophthora* in Taiwan

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ABSTRACT

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A dichotomous key and a synoptic key have been prepared for the identification of 23 species of *Phytophthora* recognized in Taiwan.

Key words: *Phytophthora*, Key, Taiwan.

Many species of the fungus genus *Phytophthora* are important plant-pathogens attacking a wide variety of crops, trees and shrubs throughout the world (23). The warm, moist oceanic climate and the continuous cropping system on a very limited arable land has made Taiwan a hotbed for *Phytophthora* diseases. To date, 38 species of *Phytophthora* have been found on over 100 different plant hosts on

the island. Based on a comprehensive study of the cultures and dried specimens of *Phytophthora* spp. reported, 23 species are recognized (6). A dichotomous key is provided to facilitate their identification, based on the terms defined by Blackwell (5). A synoptic key has also been prepared to accommodate the variation in morphological characters among isolates.

A Dichotomous Key to Taiwan Species of *Phytophthora*

- | | |
|--|--------------------------------|
| 1. Fungus cannot be cultured on agar media | 2 |
| 1. Fungus can be cultured on agar media | 5 |
| 2. Oogonia over 50 μ m diam. | 3 |
| 2. Oogonia under 50 μ m diam. | 4 |
| 3. Antheridia paragynous | <i>macrospora</i> ¹ |
| 3. Antheridia amphigynous | <i>leersiae</i> |
| 4. Sporangia oblong-ovoid (length/breadth: 1.6-1.7) | <i>cyperi</i> |
| 4. Sporangia spherical-ovoid (length/breadth: 1.1-1.2) | <i>lepironae</i> |
| 5. Sex organs produced readily in single culture | 6 |
| 5. Sex organs not or scarcely produced in single culture | 13 |
| 6. Antheridia absent | <i>insolita</i> |
| 6. Antheridia present | 7 |
| 7. Antheridia predominantly paragynous | 8 |
| 7. Antheridia amphigynous | 9 |
| 8. Sporangia non-papillate | <i>humicola</i> |
| 8. Sporangia semi-papillate | <i>citricola</i> |
| 8. Sporangia papillate | <i>cactorum</i> |
| 9. Sporangia non-papillate | 10 |
| 9. Sporangia papillate | 11 |
| 10. Good growth on agar at 35 C | <i>drechsleri</i> |
| 10. No or slight growth on agar at 35 C | <i>vignae</i> |
| 11. Oogonia spherical | <i>boehmeriae</i> |
| 11. Oogonia pyriform with tapered base | 12 |

12. Oogonial wall smooth	<i>heveae</i>
12. Oogonial wall verrucosae	<i>katsurae</i>
13. Sporangia non-papillate	14
13. Sporangia papillate to semi-papillate	15
14. Hyphae coralloid, with large spherical swellings in clusters	<i>cinnamomi</i>
14. Hyphae uniform to uneven, with small swellings in network; sporangia regularly ovoid to obpyriform in short, close sympodia; mostly no or limited growth at 35 C	<i>cryptogea</i>
14. Hyphae uniform to uneven, sometimes with small swellings; sporangia ovoid or ellipsoidal, usually single, terminal on unbranched or lax sympodially branched sporangiophore; good growth at 35 C	<i>drechsleri</i>
15. Sporangiphore branching compound sympodial, nodose	<i>infestans</i>
15. Sporangiphore branching simple sympodial, undifferentiated	16
16. Sporangia non-deciduous	17
16. Sporangia deciduous	18
17. Good growth on agar medium at 35 C, mycelium tufted	<i>nicotianae (parasitica)</i>
17. No or slight growth on agar medium at 35 C, mycelium finely radiate	<i>citrophthora</i>
18. Sporangial pedicel over 20 μ m long	<i>capsici</i>
18. Sporangial pedicel 5–20 μ m long	19
18. Sporangial pedicel under 5 μ m long	20
19. Sporangia regularly elongate, ellipsoidal to fusiform	<i>colocasiae</i>
19. Sporangia ellipsoidal to variable, often asymmetrical, bifurcate	<i>meadii</i>
20. Sporangia broadly ellipsoidal to obturbinate (length/breadth under 1.4) in short irregular sympodia	<i>arecae</i> ²
20. Sporangia ovoid to ellipsoidal (length/breadth over 1.4) in long regular sympodia	<i>palmivora</i>

1. Treated as *Sclerophthora macrospora* (22)

2. Treated as conspecific with *P. palmivora* (13)

A Synoptic Key to Taiwan Species of *Phytophthora*

Species Number	Species name and first report (reference No.) in Taiwan
1.	<i>P. arecae</i> (Coleman) Pethybridge (Huang, unpublished)
2.	<i>P. boehmeriae</i> Sawada (19)
3.	<i>P. cactorum</i> (Lebert & Cohn) Schroeder (19)
4.	<i>P. capsici</i> Leonian (9)
5.	<i>P. cinnamomi</i> Rands (4)
6.	<i>P. citricola</i> Sawada (19)
7.	<i>P. citrophthora</i> (R. E. Smith & E. H. Smith) Leonian (15)
8.	<i>P. colocasiae</i> Raciborski (14)
9.	<i>P. cryptogea</i> Pethybridge & Lafferty (8)
10.	<i>P. cyperi</i> (Ideta) Ito (10)
11.	<i>P. drechsleri</i> Tucker (melonis Katsura) (9)
12.	<i>P. heveae</i> Thompson (1)
13.	<i>P. humicola</i> Ko & Ann (11)
14.	<i>P. infestans</i> (Montagne) de Bary (10)
15.	<i>P. insolita</i> Ann & Ko (3)
16.	<i>P. katsurae</i> Ko & Chang (12)
17.	<i>P. leersiae</i> Sawada (20)
18.	<i>P. lepironae</i> Sawada (18)
19.	<i>P. macrospora</i> (Saccardo) Ito & Tanaka (19)
20.	<i>P. meadii</i> McRae (2)
21.	<i>P. nicotianae</i> Breda de Haan (<i>P. parasitica</i> Dastur) (21)
22.	<i>P. palmivora</i> (E. Butler) E. Butler (7)
23.	<i>P. vignae</i> Purss (9)

Isolation on common agar media

- (1) (A) No growth: **10,17,18,19**
- (B) Steady growth: **1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,20,21,22,23**

Sporangium and sporangiophore

- (2) Ability to produce sporangia
 - (A) Sporangia produced abundantly on agar medium: **1,2,3,4,7,8,14,20,21,22**
 - (B) Sporangia produced sparsely on agar medium: **2,3,4,5,6,7,9,11,12,16,21**
 - (C) Sporangia produced only in water: **5,6,9,11,13,15,23**
 - (D) Sporangia produced only on host: **10,18,19**
 - (E) Sporangia unknown: **17**
- (3) Sporangiophore branching
 - (A) Branching compound sympodial (with nodal swellings): **14**
 - (B) Branching simple sympodial or irregular: **1,2,3,4,5,6,7,8,9,10,12,16,19,20,21,22**
 - (C) Branching “umbellate”: **4**
 - (D) Mostly unbranched: **5,6,8,9,10,11,12,13,15,16,18,23**
- (4) Caducity of sporangium
 - (A) Deciduous; pedicel under 5 μm : **1,2,3,10,14,18,22**
 - (B) Occasionally deciduous; pedicel under 5 μm : **21**
 - (C) Deciduous; pedicel 5–20 μm : **8,19,20**
 - (D) Occasionally deciduous; pedicel 5–20 μm : **7**
 - (E) Deciduous or occasionally deciduous; pedicel over 20 μm : **4**
 - (F) Non-deciduous: **5,6,7,9,11,12,13,15,16,21,23**
- (5) Papillation of sporangium
 - (A) Papillate, apical thickening deep, hemispherical: **1,2,3,4,7,12,16,20,21,22**
 - (B) Papillate, apical thickening not as deep, less than hemispherical: **4,7,8,14**
 - (C) Semi-papillate, apical thickening shallow, under 3 μm deep: **6,7,8,10,14,18,19**
 - (D) Non-papillate, with no, or very shallow apical thickening: **5,9,11,13,15,23**
- (6) Sporangial apex
 - (A) Often more than one: **2,4,6,7,20,21**
 - (B) Usually one only: **1,3,5,8,9,10,11,12,13,14,15,16,18,19,22,23**
- (7) Proliferation of sporangium
 - (A) Proliferating internally: **5,9,11,13,15,23**
 - (B) Not proliferating internally: **2,3,4,6,7,8,10,12,14,16,18,19,20,21,22**
- (8) Width of exit pore
 - (A) Narrow (usually 5–7 μ): **2,3,4,6,7,8,10,12,14,16,18,19,20,21,22**
 - (B) Broad (usually 10–12 μ): **5,9,11,13,15,23**
- (9) Shape of sporangium
 - (A) Spherical to nearly spherical (length/breadth: 1.0–1.2): **2**
 - (B) Broadly ovoid or obturbinate (length/breadth: 1.1–1.4): **1,2,3,4,5,9,12,15,16,18,21,22**
 - (C) Ovoid, limoniform or obpyriform (length/breadth: 1.4–1.6): **1,3,4,5,6,7,9,11,12,13,14,15,16,21,22,23**
 - (D) Obpyriform, ovoid to ellipsoidal (length/breadth: 1.6–1.9): **4,5,7,8,10,11,14,19,20,22,23**
 - (E) Ellipsoidal, obovoid or elongated (length/breadth: over 1.9): **4,8,20**
 - (F) Sporangium often asymmetrical, irregular, bifurcate or trifurcate in water: **6,7**
- (10) Size of sporangium
 - (A) Under 35 μm long: **3,12,16**
 - (B) 35–55 μm long: **1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,18,20,21,22,23**
 - (C) Over 55 μm long: **4,5,6,7,8,9,11,13,19,20,21,22**

Sex organs

- (11) Ability to produce sex organs in culture
 (A) Sex organs produced readily in single culture: **2,3,6,11,12,13,15,16,23**
 (B) Sex organs produced in intra- or inter-specific crossing: **1,4,5,7,8,9,11,14,20,21,22**
- (12) Antheridial type
 (A) Antheridia absent: **15**
 (B) Antheridia paragynous: **10,18,19**
 (C) Antheridia predominantly paragynous: **3,6,10,13**
 (D) Antheridia amphigynous: **1,2,4,5,7,8,9,11,12,14,16,17,20,21,22,23**
- (13) Size of antheridium
 (A) Under 12 μm long: **3,9,12,16,21**
 (B) 12–20 μm long: **1,2,3,4,5,6,7,8,9,10,11,13,14,20,21,22,23**
 (C) Over 20 μm long: **5,17,18,19**
- (14) Cellular composition of antheridium
 (A) Unicellular: **1,2,3,4,6,7,8,9,10,11,12,13,14,16,17,18,19,20,21,22,23**
 (B) Predominantly unicellular: **5,11,12,16,23**
 (C) Unicellular or bicellular, in varying proportion: **5**
- (15) Shape of oogonium
 (A) Spherical: **1,2,3,4,5,6,7,8,9,10,11,13,14,15,18,19,20,21,22,23**
 (B) Pyriform with tapered base: **12,16,17**
- (16) Size of oogonium
 (A) Under 30 μm diam.: **2,3,6,9,12,16,21,22**
 (B) 30–35 μm diam.: **1,3,4,6,7,8,9,11,15,20,21,22,23**
 (C) 35–40 μm diam.: **4,5,10,11,13,14**
 (D) 40–50 μm diam.: **5,10,13,17,18,19**
 (E) Over 50 μm diam.: **17,19**
- (17) Surface morphology of oogonium
 (A) Smooth: **1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,19,21,22,23**
 (B) Roughened with age: **4,7,8,14,21**
 (C) Granular with small irregular rounded papillae: **19**
 (D) Verrucose: **16**
 (E) Unevenly folded or undulated: **17**
- (18) Thickness of oogonial wall
 (A) 1–2 μm or less: **1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,20,21,22,23**
 (B) 3–5 μm or more: **17,18,19**
- (19) Size of oospores
 (A) Under 25 μm diam.: **2,3,6,7,8,9,12,16,20,21,22**
 (B) 25–30 μm diam.: **3,4,9,11,15,21,22,23**
 (C) 30–35 μm diam.: **10,11,13,14**
 (D) 35–40 μm diam.: **10,18**
 (E) Over 40 μm diam.: **17,19**
- (20) Oospore size relative to the oogonium
 (A) Oospore filling the oogonium: **19**
 (B) Oospore nearly filling the oogonium: **1,2,3,5,6,9,10,11,14,15,18,21,22**
 (C) Oospore loose in the oogonium: **4,6,7,8,10,12,13,16,17,20,21,22,23**
- (21) Thickness of oospore wall
 (A) 1–3 μm : **1,2,3,4,5,6,7,8,9,10,11,12,14,16,20,21,22,23**
 (B) 3–5 μm : **5,9,11,13,15,17,18**
 (C) Over 5 μm : **13,17,19**

Chlamyospore

- (22) Ability to produce chlamyospores in culture
(A) Chlamyospores abundant: **1,2,5,15,21,22**
(B) Chlamyospores occasionally formed: **1,3,4,5,7,8,21**
(C) Chlamyospores absent: **3,4,5,6,7,8,9,10,11,12,13,14,16,17,18,19,20,23**
- (23) Thickness of chlamyospore wall
(A) 1 μm or less: **5,15**
(B) 1–2 μm : **1,2,3,4,7,8,21,22**
(C) 3–4 μm : **21**

Mycelium

- (24) Appearance of hyphae on agar medium
(A) Hyphae uniform to uneven, freely branching: **1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,20,22,23**
(B) Hyphae irregular, clustered or tufted: **5,21**
(C) Hyphae coralloid: **5**
- (25) Ability to produce hyphal swellings in water
(A) Swellings abundant: **5,9,13,15,21**
(B) Swellings occasionally formed: **11,21,23**
(C) Swellings rare or absent: **1,2,3,4,6,7,8,12,14,16,20,22,23**
- (26) Size, shape and arrangement of hyphal swellings
(A) Small, under 25 μm ; spherical to angular, single, terminal or intercalary: **11,23**
(B) Small, under 25 μm ; spherical to angular, in conspicuous network: **9**
(C) Small, under 25 μm ; spherical with radiating hyphae: **21**
(D) Large, 25–50 μm ; spherical with radiating hyphae, mostly intercalary: **13**
(E) Large, 25–50 μm ; spherical, clustered or single, mostly terminal: **5**
(F) 25–45 μm ; spherical to oval, terminal or intercalary, many lateral in position: **15**
- (27) Colony morphology on V-8 agar medium
(A) Uniform: **1,2,3,4,5,6,8,9,11,13,14,16,20,21,22,23**
(B) Radiate: **1,3,4,5,6,7,9,11,12,16,22**
(C) Finely radiate: **7**
(D) Stellate: **4,6,7,12,15,20,22**
(E) Rosette: **4,11**
(F) Distinctly tufted or mosaic: **21**
- (28) Maximal temperature for growth
(A) Under 30 C: **14**
(B) 30–35 C: **1,2,3,5,6,7,8,9,12,13,16,20,22,23**
(C) Over 35 C: **4,5,9,11,15,21**

Host specificity

- (29) (A) On *Colocasia esculenta* (*C. antiquorum*) (taro, dasheen): **8**
(B) On *Cyperus* spp.: **10**
(C) On *Leersia hexandra*: **17**
(D) On *Lepironia articulata* (*L. mucronata*): **18**
(E) On *Oryza sativa* (rice) and other Gramineae: **19**
(F) On *Solanum tuberosum* (potato): **14**
(G) On *Vigna* (cowpea): **23**

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摘 要

何漢興。1992。臺灣疫病菌屬種之檢索表。植病會刊 1:104-109。(美國紐約州立大學新柏茲分校生物系)

本植物疫病菌之檢索表提供便捷方法，以鑑定臺灣現有已認知的二十三種疫病菌，檢索表是依傳統式二分法和要略式編成的。

關鍵字：疫病菌、檢索表、臺灣。