

Distribution of the A¹ Mating Type of *Phytophthora cinnamomi*

G. A. Zentmyer

Professor of Plant Pathology, University of California, Riverside, CA 92502.

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ABSTRACT

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Our isolations and reports in the literature show that the A¹ compatibility or mating type of *Phytophthora cinnamomi* has a more limited distribution, both geographically and by host, than the A² type. The A¹ type has been reported from Australia, Malagasy Republic (Madagascar), Papua New Guinea, South Africa, and the United States; the host list for

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the A¹ type includes only 11 plants in 10 genera. The A² type is world-wide in distribution, and has several hundred hosts. Most of the A¹ isolates resemble the type culture in cultural appearance, although some vary considerably phenotypically and in growth rate.

The current designations of compatibility or mating type in the genus *Phytophthora* were established in 1958 when Gallegly and Galindo (6) designated A¹ and A² types of *P. infestans*. Since that time the compatibility types of the other heterothallic species of *Phytophthora* have been related to the A¹ and A² types of *P. infestans* (14). In areas where both mating types are present there is greater opportunity for recombination and variation through the sexual stage, hence information on distribution and host specificity of the two types is of potential significance in relation to disease development.

The two compatibility or mating types of *Phytophthora cinnamomi* Rands have been known since the first report of the A¹ type in April 1962 (19). Previously, there had been reports of oospore formation when *P. cinnamomi* was paired with several other species of *Phytophthora* (1, 2, 3, 17), but the compatibility types were not identified.

The first isolation of the A¹ compatibility type of *P. cinnamomi* was made by the author in 1961 from a canker on the trunk of a macadamia tree (*Macadamia integrifolia* Maiden & Betche) on the island of Hawaii. Other cultures obtained from cankers on macadamia trees in California, and on the island of Oahu (11, 18) were all of the A² compatibility type of *P. cinnamomi*. Galindo and Zentmyer (5) presented a detailed report on the A¹ mating or compatibility type of *P. cinnamomi* in 1964. This paper summarizes the distribution of this type by host and country and compares the phenotype and growth rate of the two types.

RESULTS AND DISCUSSION

Phytophthora cinnamomi has a world-wide distribution, particularly in subtropical and tropical areas (Commonwealth Mycological Institute Map No. 302). The majority of these isolates are the A² type. For example, our collection of *P. cinnamomi* isolates totals 286 cultures from 32 countries and 70 host species. Only 20 of these cultures are of the A¹ mating type.

Based on the isolates in our *Phytophthora* culture

collection, on records at the Commonwealth Mycological Institute provided by Jean Stamps, and on published reports, the A¹ type has been found in only Australia, Malagasy Republic (Madagascar), Papua New Guinea, South Africa, and the United States. Ten genera of plants are involved as hosts. More detailed information on these isolates follows.

Australia.—Pratt et al. (13) first reported the occurrence of the A¹ type in eastern and western Australia. In Queensland, this type was isolated from *Casuarina littoralis* Salisb., whereas in New South Wales isolations from *Eucalyptus globoidea* Blakely and *Banksia* sp. were of the A¹ compatibility type. In Western Australia, the A¹ type was found in isolates from *Aotus passerinoides* Meissn. and from soil in the *Eucalyptus marginata* forest.

In 1974, Pegg (12) reported on tests of mating types with 172 isolates from southeastern Queensland; 154 of these were A² and 18 were A¹. Isolates from avocado, pineapple, macadamia, and pine (*Pinus radiata* D. Don) were A². Isolates from "Wallum areas" (coastal lowlands) which included the following host genera: *Banksia*, *Casuarina*, *Tristania*, *Acacia*, *Elaeocarpus*, *Pultenaea*, *Homoranthus*, and *Eriostemon*, were mixtures of A¹ and A² types; but specific hosts for the A¹ type were not designated. According to recent information (Pegg, *personal communication* November 1974), the A¹ type was isolated in Queensland from roots of *Banksia aemula* Br., and *Casuarina littoralis*, and was baited from soil under plants of *Tristania conferta* R. Br. and *Acacia ulicifolia* Salisb.

The Australian A¹ isolates in our collection (Fig. 1) are similar in cultural appearance on potato-dextrose agar (PDA) to the type culture but tend to grow more slowly at 24 C than the type culture.

Malagasy Republic (Madagascar).—The A¹ isolates from avocado in the Malagasy Republic were sent to us by M. Tarjot, Ivory Coast, and originally were isolated by J. Brun. These cultures are similar to the type.

Papua New Guinea.—In the first report of *P. cinnamomi* from this country, Shaw et al. (15) isolated the

A¹ type from soil under dead indigenous *Nothofagus* trees in the highlands. This culture is merely a growth-rate variant of Rands' type culture.

South Africa.—Isolates of the A¹ type of *P. cinnamomi* were sent to our laboratory by H. T. Brodrick, Nelspruit, South Africa. These and A² cultures were isolated by Brodrick from grape roots, and are typical *P. cinnamomi* cultures.

United States.—In addition to the A¹ isolate from Hawaii noted above, this type has been cultured from California, Georgia, and North Carolina. The A¹ type from macadamia differs phenotypically and in growth rate from the type culture (Fig. 1). It grows more slowly on PDA at 24 C but has a higher maximum temperature for growth than most isolates of *P. cinnamomi*, making significant growth at 33 C on PDA.

In California, the A¹ type was isolated from root and crown rot of *Camellia japonica* L. by the author in 1965. All of our camellia isolates have been of the A¹ type. The A² type is the common type in most hosts in California, including avocado, azalea, *Ceanothus*, many conifers, heather, macadamia, *Myrtus*, and rhododendron. *Phytophthora cinnamomi* is a common and severe pathogen on thousands of acres of avocado trees in

southern California; all of our isolates are A² except for one culture provided by the State Department of Agriculture from a grove in Santa Barbara. This A¹ isolate may have been moved into the avocado grove from ornamental plantings around a house on the property. A culture sent to us by E. Trujillo from *Thuja* sp. in Hawaii is also the A¹ type.

Gill (8) originally reported *P. cinnamomi* on camellia in Georgia; this is now known to be the A¹ type. Reports from North Carolina (9, 10) showed the presence of the A¹ compatibility type on *Camellia japonica* but some isolates formed oospores with other camellia isolates, thus indicating that both mating types occur on camellia. In a later, more complete paper (10) Haasis and Nelson only list "—" types (equivalent to A¹) on camellia and make no mention of their previous report of both types; thus, the early report seems open to question. *P. cinnamomi* has been isolated from camellia in Florida, but we do not have this isolate, and the compatibility type was not determined. Haasis et al. (10) reported that one of their isolates from *Rhododendron* (hybrid) in North Carolina was the "—" or A¹ type; this is the only record of this mating type on *Rhododendron*.

The A¹ type isolates of *P. cinnamomi* are somewhat

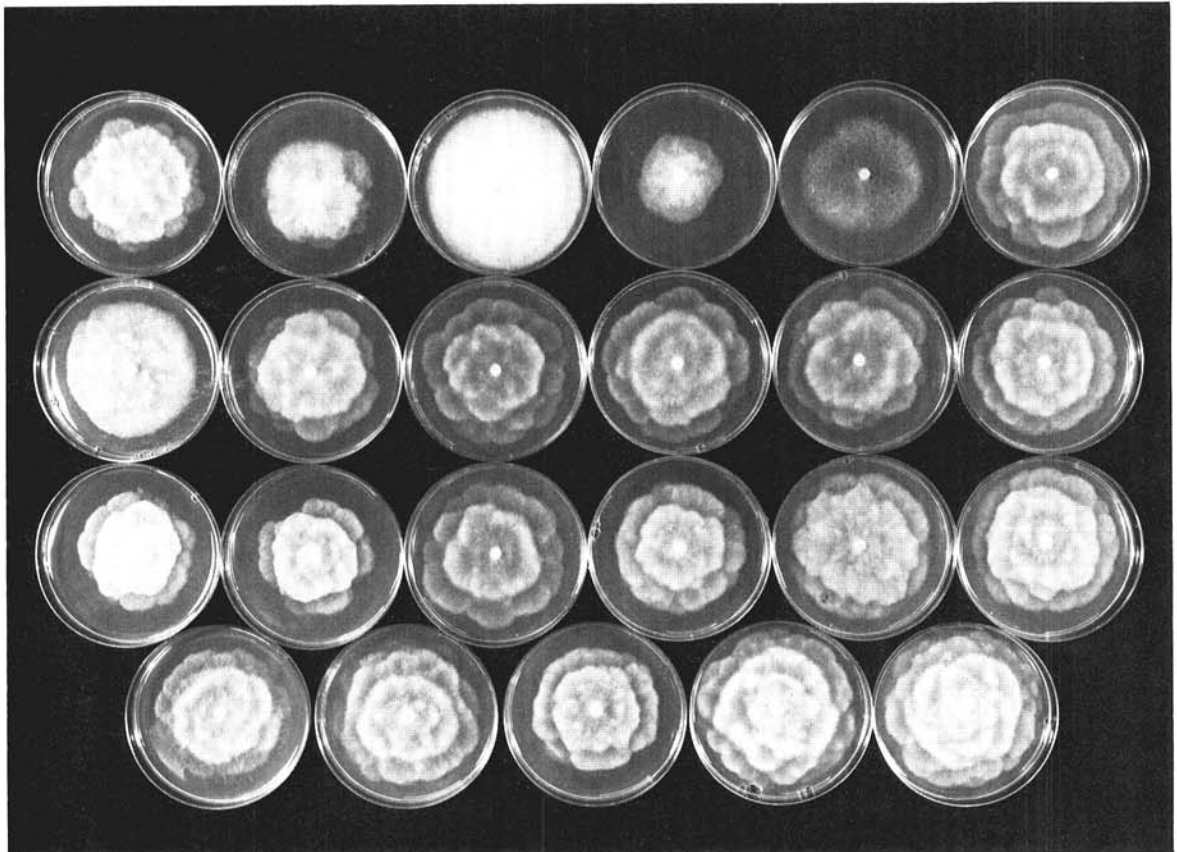


Fig. 1. A¹ cultures of *Phytophthora cinnamomi*, compared with type culture (A²), bottom row, far right; and A² culture from avocado, California (bottom row, second from right). Left to right, **top row**, cultures from: *Camellia*, California; *Thuja*, Hawaii; *Macadamia*, Hawaii (sector from original isolate); *Macadamia*, Hawaii; *Camellia*, North Carolina; *Camellia*, California. **Second row**: all cultures from *Camellia*, California. **Third row**: *Persea americana*, Malagasy Republic (two isolates); *Persea americana*, California; *Tristania conferta*, Australia; *Vitis*, South Africa (two isolates). **Bottom row**: *Camellia*, California; soil around *Nothofagus*, Papua New Guinea; *Eucalyptus globoidea*, Australia; A², *Persea americana*, California; A², *Cinnamomum burmanni*, Sumatra (type culture). All cultures grown at 24 C for 5 days on potato-dextrose agar.

variable in cultural appearance, although the majority resemble Rands' type culture (Fig. 1). The A¹ types grow more slowly on PDA than most of the A² types, as noted in Fig. 1 in which all cultures were grown for 5 days at 24 C.

The A¹ type will undoubtedly be identified in other locations and on other hosts in the future, but it is obviously the more restricted type of this species, being limited in both host and geographical distribution.

The only other species of *Phytophthora* on which there is considerable information on mating type distribution are *P. infestans* and *P. palmivora*. With *P. infestans* the A¹ type is distributed world-wide, whereas the A² type is restricted to Mexico (4, 7, 16). In the case of *P. palmivora*, both mating types are distributed widely (20).

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