Foliar Stage of Phytophthora Blight of Macadamia

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ABSTRACT

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Blighting of shoot terminals and young, unexpanded apical leaves of *Macadamia integrifolia* were shown to be caused by *Phytophthora capsici* and *P. palmivora*. Under greenhouse conditions, *P. capsici* remained viable on blighted leaves for at least 6 mo. Isolates of *P. capsici* from pepper, papaya, anthurium, and macadamia raceme and isolates of *P. palmivora* from Vanda, English ivy, papaya, and macadamia raceme all induced foliar blights of macadamia. Application of the name *P. capsici* to isolates with deciduous, long-pedicellate sporangia is briefly discussed.

Phytophthora blight of macadamia (*Macadamia integrifolia* Maiden & Betche) occurs sporadically on racemes and nuts during prolonged wet periods, although occasional extensive losses have been incurred by growers (6). Leaves are apparently unaffected (6). The more prevalent of two causal fungi was originally called *Phytophthora nicotianae* B. deHaan var. *parasitica* (Dast.) Waterhouse but has since been referred to as *P. capsici* Leonian (9). The second species is *P. palmivora* (Butl.) Butl.

In outbreaks of macadamia raceme blight at Keaau on the island of Hawaii in January 1975 and February 1979, leaf and shoot blights were also evident on several trees. Only the tender, expanding young leaves and elongating green shoots were affected with extensive dark necrosis of irregular shape. Both *P. capsici* and *P. palmivora* were recovered from blighted tissue, with the former more prevalent. A similar macadamia leaf blight caused by *P. palmivora* has been reported from Costa Rica (3).

The foliar disease in Hawaii appeared to have little significant direct effects on the nut-bearing capacity of the tree, although the foliar blight may serve as a possible means of carrying the pathogen over from one flowering season to the next. Inoculation studies were done to demonstrate the pathogenicities of the two fungi to macadamia foliage.

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MATERIALS AND METHODS

P. capsici isolates used were P209, one of the original raceme blight isolates (6); P231, macadamia soil isolate from Haiku, Maui; P248, leaf blight isolate from Keaau; P287, from pepper (*Capsicum annuum* L.); P223, from papaya (*Carica papaya* L.) fruit rot; P283, from

anthurium (*Anthurium andreanum* Lind.) flower blight; P250 from macadamia flower, Waikea Uka; and P243 from macadamia flower, Keaau. *P. palmivora* isolates used were P249, from a blighted macadamia raceme axis, and P242, from a macadamia shoot blight, both from Keaau; P176, from Vanda orchid; P233, from English ivy (*Hedera helix* L.); and P268, from papaya. Culture numbers refer to isolates maintained in the *Phytophthora* stock collection in the Department of Plant Pathology, University of Hawaii. Inoculum was prepared by growing all cultures on vegetable juice agar (10% Campbell's V-8 juice, 0.2% $CaCO_3$, and 1.8% agar) at 28 C under continuous fluorescent light (cool white, 2,200 lux). *P. capsici* cultures were grown for 10 days and *P. palmivora* for 6 days to produce sufficient sporangia. Zoospore suspensions were prepared by flooding cultures with deionized water and dislodging sporangia by rubbing with a rubber spatula. Zoospore discharge occurred in 20 min, and concentrations were adjusted to 1×10^5 zoospores per milliliter. These were sprayed onto macadamia seedlings 30–40 cm tall with several tender, expanding leaves; three seedlings were used for each isolate. Inoculated plants were incubated in moist chambers in the greenhouse for 24 hr, then returned to benches for 7 days, at which time observations were made. Controls were sprayed with deionized water and incubated similarly. All tests were repeated.

In a study of persistence of *P. capsici* on macadamia foliage, isolates P209 and P248 from macadamia flower and leaf, respectively, were used to inoculate 10 macadamia seedlings each. The inoculation procedures and host plant characteristics were as described, and the plants were subsequently maintained in the greenhouse for 6 mo, the duration of the study. Leaf lesions were sampled for pathogen viability at weekly or biweekly intervals for the first 2 mo and at the fourth and sixth month after inoculation. Leaf tissue with lesions was surface-sterilized in 0.25% sodium hypochlorite and plated on water agar.

RESULTS

All 13 test isolates were virulent to macadamia foliage. Isolation of *P. capsici* was considered sufficient presumptive evidence for reisolation of all isolates, inasmuch as no markers were available for cultural identification. Similarly, isolation of *P. palmivora* was considered sufficient evidence for recovery of P249, P176, P233, P268, and P242. No lesions developed on controls.

Fully expanded, hardened, older leaves were not affected by any isolate. Circular brown spots restricted to 1–2 cm in diameter developed on fully expanded younger leaves. Dark-brown irregularly shaped lesions as long as 6–7 cm developed on expanding young leaves, frequently extending along the midrib or completely blighting the distal one-third to two-thirds of a leaf. Infections of very young leaves up to 4 cm in length usually resulted in necrosis of the entire leaf. Disease severity varied considerably among seedlings inoculated with the same isolate. Plants with several expanding, succulent leaves were severely blighted, whereas disease development was minimal on plants with fewer immature leaves. Foliar blight severity of inoculated plants varied as much within *P. capsici* and *P. palmivora* isolates as between the two species. This conforms with our observations that these organisms cannot be distinguished in the field by symptoms.

Both isolates of *P. capsici* used in the study on pathogen persistence on foliage were recovered from macadamia leaves throughout the 6 mo of the study. Recovery from the advancing necrotic margins, especially those containing midrib sections, was good, whereas the fungus could not be isolated from dried, completely necrotic tissue.

DISCUSSION

Phytophthora blight of macadamia has been known in Hawaii for nearly 10 yr, but observation of the foliar stage has been infrequent. This can be surmised in the statement of Hunter et al (6) that leaves are apparently unaffected. The relative rarity of the foliar stage indicates that it has little, if any, direct economic significance at present. To sustain this status, possible susceptibility of any new cultivar should be ascertained before extensive acreages are planted. Although direct economic effects of the foliar stage of Phytophthora blight may be insignificant, its possible role in perpetuating the disease cycle should not be overlooked. Hunter et al (6) showed that *P. capsici* persists on naturally blighted racemes between flowering seasons, and our study showed that the fungus also persists on diseased foliage. Fungal survival on blighted racemes and vegetative shoots during the extended nonflowering period, which includes drier summer months, may contribute to rapid establishment of raceme blight during the rainy winter period.

Placement of the causal organism of macadamia raceme blight in *P. capsici* in 1976 (9) coincided with a renewed interest in characterization, identification, and nomenclature of *Phytophthora* isolates with deciduous, long-pedicellate sporangia. Certain isolates from cacao, characterized by sporangia that are shed with long pedicels, were designated MF4 of *P. palmivora* at the Cocoa Phytophthora Workshop in 1976 (5). The macadamia isolates of *P. capsici* are similar to these MF4 types (1,4,12) as well as to black pepper *Phytophthora* isolates (10) and certain isolates from papaya, anthurium, and *Leucospermum* (2). Furthermore, the black pepper and MF4 isolates have been considered to be the same fungus and distinct from *P. palmivora* (4). Brasier and Griffin (4) point out that Waterhouse was the first to suggest that *Phytophthora* isolates from *Piper* spp. may represent species other than *P. palmivora* (11), but her observation that these isolates produce noncaducous sporangia does not conform to observations of black pepper isolates by others (1,4,10).

Although the designation of *P. capsici* to macadamia isolates has been questioned (10,12), obvious similarities between *P. capsici* and MF4 isolates have been observed in other studies (8), and Kaosiri has concluded that MF4 is *P. capsici* (7). Studies on the characterization and taxonomy of these organisms are continuing in our laboratory and presumably by the other groups mentioned (1,4,7,8,10,12).

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