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# Disease Risk of Potting Media Infested with *Phytophthora ramorum* Under Nursery Conditions

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**ABSTRACT**

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*Phytophthora ramorum* has been found in potting media of containerized plants; however, the role of infested media on disease development under nursery conditions is unknown. This study assesses pathogen survival, sporulation, and infectivity to rhododendron plants in nursery pots with infected leaf litter that were maintained under greenhouse and field conditions. The influence of environmental conditions and irrigation method on disease incidence was also assessed. Infected leaf disks were buried below the soil surface of potted rhododendrons and retrieved at approximately 10-week intervals for up to 66 weeks. Pathogen survival was assessed by either isolation or induction of sporulation in water over three experimental periods. *P. ramorum* was recovered from infected leaf disks incubated in planted pots for longer than 1 year. Chlamydospores and sporangia formed on hydrated leaf disks but relative production of each spore type varied with the duration of incubation in soil. Root infections were detected after 40 weeks in infested soil. Foliar infections developed on lower leaves but only after spring rain events. Sprinkler irrigation promoted the development of foliar infections; no disease incidence was observed in drip-irrigated plants unless foliage was in direct contact with infested soil. Management implications are discussed.

*Phytophthora ramorum*, the causal agent of sudden oak death (SOD), produces trunk cankers and widespread mortality on tanoak (*Lithocarpus densiflorus*) and oak (*Quercus* spp.) (17) and leafspots and blights on numerous other native hosts in California and Oregon woodlands (1,3). The pathogen was described as a new *Phytophthora* spp. in 2001 but it was observed as early as 1993 to cause leaf blights and mortality on rhododendron and viburnum in nurseries and public gardens in Germany and The Netherlands (24). With the association of *P. ramorum* with SOD, intensive nursery stock and public garden inspections ensued, resulting in documentation of the pathogen in several European countries. In December 2000, *P. ramorum* was first discovered infecting rhododendron nursery stock in California (10). By 2003, agricultural inspectors found the pathogen infecting nursery stock in California, Oregon, Washington, and British Columbia, Canada. In 2004, the disease became a national concern when a large wholesale nursery in California shipped camellia plants infected with *P. ramorum* to nurseries and other customers in 40 states. Presently, Animal and Plant Health and Inspection Service Plant Protection and Quarantine lists 110 plant taxa as proven or associated hosts (1). State, federal, and international quarantine restrictions have been placed on the movement of plants or plant parts of these listed hosts.

In addition to causing aboveground cankers and leaf blights, *P. ramorum* can survive in soil and can serve as an inoculum reservoir for both root and shoot infections. *P. ramorum* survived in infected camellia leaf tissue buried for almost 2 years and in root pieces up to 11 months in laboratory and greenhouse conditions, respectively (19). Furthermore, the pathogen survived in various potting media or soil for up to 6 months as sporangia or 12 months as chlamydospores (13). Infected rhododendron leaf disks buried in California forest soil retained 60% pathogen survival over the summer (7) and up to 80% survival after a year-long incubation initiated during the winter rainy season (E. Fichtner, *unpublished data*). This demonstrated survival potential of *P. ramorum* in both forest soils and in various potting media suggests their role as an inoculum reservoir in both natural ecosystems and in nurseries.

*P. ramorum* in infested soil has been shown to serve as primary inoculum for root and foliar infections. Under laboratory conditions, foliar infections of bay laurel were induced by splash dispersal of inoculum from infested soil covered with bay laurel green leaf litter (4). Similarly, in situ studies in a California forest demonstrated that splash dispersal of infested soil after rain events can infect tanoak and bay laurel foliage up to 30 cm above the forest floor in both the presence and absence of a leaf litter layer (E. Fichtner, *unpublished data*). *P. ramorum* has been shown to cause asymptomatic infections of rhododendron roots in infested U.K. woodlands (8) and of potted rhododendrons grown in artificially infested potting medium (16). Additional laboratory studies demonstrated that *P. ramorum* may infect roots of weeds found in ornamental container culture (20) and roots of numerous nursery ornamental plants (19). In commercial nurseries, *P. ramorum* has been detected both beneath and within containers of asymptomatic nursery stock, demonstrating the potential for undetected pathogen movement in the nursery stock trade (2).

Long-term survival of *P. ramorum* in container and field soil may at least partially explain the challenge of eradication efforts, but the influence of nursery practices and environmental conditions on pathogen longevity, transmission, and infectivity in infested containers under nursery conditions are unknown.

The epidemiological importance of infected leaf litter in potting soil in transmission and survival of *P. ramorum* in container-grown rhododendrons was assessed under outdoor-nursery and greenhouse conditions. The objectives of this study were to (i) determine in situ survival potential of *P. ramorum* in potting media; (ii) investigate the relative production of sporangia and chlamydospores on buried, infected leaf litter over time; (iii) assess potential for pathogen transmission from infected leaf litter to aboveground plant parts and roots; and (iv) investigate the influence of rain events and irrigation practices on foliar disease incidence in pots containing infected leaf litter. The results from these experiments will help assess disease risk associated with soilborne inoculum and provide information for the development of improved nursery practices for disease management.

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