

Susceptibility of some Eastern Oak Species to Sudden Oak Death caused by *Phytophthora ramorum*

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INTRODUCTION

Phytophthora ramorum causes Sudden Oak Death, a disease responsible for mortality of tanoak (*Lithocarpus densiflorus*), coast live oak (*Quercus agrifolia*) and California black oak (*Q. kelloggii*) along the California coast and up into Oregon (Rizzo et al, 2002a; Werres et al, 2001). *P. ramorum* has been found to have a wide host range, with 23 species in 12 plant families currently determined to be naturally infected by the pathogen (Davidson et al, 2002; 2003; Maloney et al, 2002). Several oak species have been previously tested by stem inoculation and found to be susceptible to *P. ramorum* (Rizzo et al, 2002a; 2002b). Oaks in the red oak group were found to be more susceptible than those in the white oak group (Rizzo et al, 2002b). To assess the threat potential of *P. ramorum* to Eastern U.S. oak forests, we performed artificial stem inoculations of 9 different oak species, sugar maple, and black walnut and foliar inoculations of 8 oak species.

MATERIALS AND METHODS

Stem inoculations. 2-3 year-old seedlings of coast live oak (*Quercus agrifolia*), northern red oak (*Q. rubra*), white oak (*Q. alba*), cherrybark oak (*Q. pagoda*), chestnut oak (*Q. prinus*), laurel oak (*Q. laurifolia*), live oak (*Q. virginiana*), water oak (*Q. nigra*), willow oak (*Q. phellos*), sugar maple (*Acer saccharum*) and black walnut (*Juglans nigra*) were inoculated by placing 6 mm-diameter agar plugs cut from the margin of 10-14 day-old cultures of *P. ramorum* isolate 0-16 (Rizzo Pr-6, from coast live oak in California) into stem wounds ca. 5 cm above the soil line and covering with parafilm. Controls received agar plugs containing no *P. ramorum*. Seedlings were then incubated in a containment greenhouse cubicle at 20 C for 72-76 days, at which time results were assessed.

Foliar inoculations. 2-3 year-old seedlings of coast live oak (*Quercus agrifolia*), northern red oak (*Q. rubra*), white oak (*Q. alba*), cherrybark oak (*Q. pagoda*), chestnut oak (*Q. prinus*), live oak (*Q. virginiana*), laurel oak (*Q. laurifolia*) and tanoak (*Lithocarpus densiflorus*) were inoculated by placing branches containing at least 15 leaves each into a plastic bag containing 5000 sporangia/ml of *P. ramorum* isolate 0-16, and shaking. Seedlings were then placed in a dew chamber at 20 C in darkness for 7 days. The amount of affected leaf tissue was determined by scanning detached leaves and measuring leaf and lesion areas with ASSESS Image Analysis software (Lamari, 2002).



Oak trees in greenhouse cubicle at 20 C for stem inoculations.

RESULTS

Lesion areas of stem-inoculated seedlings ranged from 0.68 to 3.20 cm² (TABLE 1). Since stem diameters varied substantially for different tree species, lesion areas were also corrected by dividing by the stem diameter. *P. ramorum* was isolated from all species on PARP selective medium from the edges of stem lesions and at points up to 4 mm away from lesion edges. *P. ramorum* was similarly isolated from leaf lesions from all 8 species in the foliar inoculations. Chestnut oak was the most susceptible species to both stem and foliar inoculation, while other species varied in susceptibility to *P. ramorum*. (TABLES 1 and 2).

TABLE 1. Results of stem inoculation of 11 forest species (9 oaks plus sugar maple and black walnut) with isolate 0-16 of *Phytophthora ramorum*. Seedlings (2-3 years old) were incubated in a greenhouse cubicle at 20 C for 72-76 days.

Species	n	Les. area (cm ²)	Corr. Les. Area (cm ²) [*]
Chestnut Oak	50	3.20 a**	3.29 a
White Oak	50	2.80 b	3.18 a
Northern Red Oak	50	2.16 c	2.08 b
Laurel Oak	50	1.76 d	1.62 c
Cherrybark Oak	50	1.55 d	1.82 bc
Willow Oak	50	1.16 e	1.25 d
Water Oak	50	1.16 e	1.26 d
Black Walnut	50	1.10 e	1.16 de
Live Oak	50	1.08 e	1.18 d
Sugar Maple	50	0.94 e	0.91 e
Coast Live Oak	150	0.68 f	1.29 d
Controls	130	0.15 g	0.24 f

^{*} corrected by dividing lesion area by stem diameter

^{**} means followed by the same letter do not differ significantly by the Waller-Duncan K-ratio t test (kratio=100)



Northern Red Oak
Isolate 0-16



Coast Live Oak
Isolate 0-16

Stem lesions caused by *P. ramorum* on northern red oak (above, left) and coast live oak (above, right) following 72-76 days of incubation in a 20 C greenhouse cubicle. Topmost stem in each picture is a control.



Sugar Maple
isolate 0-16

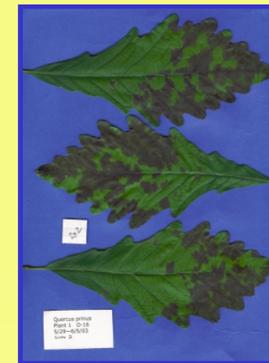


Black Walnut
isolate 0-16

Stem lesions caused by *P. ramorum* on sugar maple (above, left) and black walnut (above, right) following ca. 2 months of incubation in a 20 C greenhouse cubicle. Bottommost stem in each picture is a control.

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Scans of foliage lesions on chestnut oak (left) and tanoak (right).

TABLE 2. Results of foliar inoculation of 8 oak species with sporangia of isolate 0-16 of *Phytophthora ramorum*. Seedlings (2-3 years old) were incubated in a dew chamber at 20 C for 7 days.

Species	n	Percent disease
Chestnut Oak	26	17.0 a [*]
White Oak	22	0.5 b
Northern Red Oak	29	2.1 b
Cherrybark Oak	13	0.2 b
Laurel Oak	18	1.6 b
Live Oak	9	0.6 b
Tanoak	25	13.2 a
Coast Live Oak	40	2.8 b

^{*} means followed by the same letter do not differ significantly by the Waller-Duncan K-ratio t test (kratio=100)



Isolation of *P. ramorum* on PARP medium from northern red oak (above, left) and sugar maple (above, right).

CONCLUSIONS

- *P. ramorum* is able, under containment greenhouse conditions, to cause lesions in stems of 10 different Eastern forest species.
- *P. ramorum* was isolated from necrotic tissue of all species tested, and from tissue up to 4 mm from the edges of stem lesions on most species.
- *P. ramorum* was able to infect foliage of the 8 oak species tested, even though foliar disease is not commonly observed in nature for species such as *Q. agrifolia* (coast live oak)
- Further research is needed to assess the likelihood of *P. ramorum* infecting Eastern forest species under natural conditions.

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