

Log Susceptibility of Iberian Tree Species to *Phytophthora ramorum*¹

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Abstract

Phytophthora ramorum is a plant pathogen introduced into Europe and North America. It can infect any host species belonging to different botanical families within the seed plants. Such infective capacity indicates that it can overcome basic plant defence responses that have been phylogenetically conserved in plants (Heath 1991). In addition, *P. ramorum* is capable of infecting woody plants that are not predisposed (i.e. physiologically healthy) and can colonize a diversity of ecological niches such as leaves, stems, trunks and maybe roots and fruits. All these traits make *P. ramorum* potentially invasive to many ecosystems worldwide. Despite this, what renders a plant species susceptible to *P. ramorum* is not well understood, but it is becoming evident that trees of certain plant families, such as the Fagaceae (*Fagus*, *Castanopsis*, *Castanea*, *Quercus*, and so forth), are much more predisposed to developing trunk cankers caused by this pathogen than any other tree species.

As part of the Risk Analysis for *Phytophthora ramorum* (RAPRA) project, a long-term study on the risk posed by *P. ramorum* to European natural ecosystems, the capacity of the pathogen to colonize the inner bark of some Iberian tree species was assessed. Twenty-one tree species were selected, including hygrophilous conifers, evergreen drought-resistant species, and those covering more than 80 percent of the overall forest surface of the Mediterranean and sub-Mediterranean vegetation of the Iberian Peninsula (Spain and Portugal). We used the log inoculation method described by Brasier and Kirk (2001) which has been used to assess the susceptibility of trees to *Phytophthora* species in the UK. Logs were cut from eight different individual trees per species in summer (June to July/2005 to 2006) and winter (Dec. to Jan. 2004 to 2006), and inoculated a day after returning to the laboratory. Five isolates, three belonging to the European lineage (EU1) and two to the North American lineage (NA1), were used. One isolate of *P. cinnamomi*, a well-known pathogen of oaks, and *P. hedraiaandra*, a recently described species, were included as positive controls. A single sterile carrot agar plug was used to inoculate each log and served as the negative control. Eight logs (10-20 cm diameter x 1.2 m long) per tree species were wound-inoculated with 7 mm diameter mycelial plugs at eight equidistant points (Brasier and Kirk 2001). At each of the eight inoculation sites, a different isolate, species, or control was used. The trunks were sealed with double polyethylene film to ensure suitable humidity and incubated at 20°C in a quarantine chamber. After approximately 40 days, the outer bark was removed, the outline of the necrotic lesion traced on transparent paper and the image scanned. The lesion area was calculated with the Olympus DP12 Soft version 3.2.

Most of the *Quercus* species ranked in the highly susceptible category with mean lesion areas on *Q. pyrenaica*, *Q. humilis*, *Q. canariensis*, *Q. faginea*, and *Q. suber* over 100 cm² and as

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high as 400 cm² in trials carried out in summer; *Q. ilex* ranked in the moderately susceptible category forming lesions up to 130 cm². As expected, *P. cinnamomi* was as highly aggressive to *Quercus* spp. as *P. ramorum*, but *P. hedraiaandra* was considerably less aggressive. However, occasionally *P. hedraiaandra* also caused large lesions (> 100 cm²) on *Quercus* spp. The holm oak (*Q. ilex*), cork oak (*Q. suber*) and Portuguese oak (*Q. faginea*) were on average slightly susceptible in the winter trials, although some individuals attained large lesion areas suggesting that some kind of a threshold effect occurred in the interaction between host-pathogen genotype pairs (*cf.* summer trials). Cork oak trees exhibited rounded bleeding lesions similar to those observed on *Q. agrifolia* in California, and the other *Quercus* species typically formed diamond-shaped lesions. Of the pines inoculated, only *Pinus halepensis* formed considerably long narrow lesions. The other four pines, *P. pinaster*, *P. pinea*, *P. nigra* and *P. sylvestris*, were resistant. Two trees belonging to the Oleaceae, *Fraxinus angustifolia* and *Olea europea*, were consistently resistant to all the *Phytophthoras* inoculated. On average, the three European isolates of *P. ramorum* formed larger lesions on susceptible hosts than the two American isolates, although differences were not statistically significant. There was also evidence of host variation in the susceptibility within a species and across seasons among some tree species tested. Our results fit the general pattern of oak susceptibility and pine resistance, and of seasonality and individual (within population) variation observed by other researchers on log inoculations performed on trees of northern Europe and North America (Brasier and others 2006, Hansen and others 2005).

Our study indicates that the living inner bark of *Quercus* species collected in the Iberian Peninsula is very susceptible to *P. ramorum*. However, we have not yet tested whether the outer bark can be an important barrier to infection by zoospores under natural conditions. At least four species (*Q. ilex*, *Q. suber*, *Q. humilis* and *Q. canariensis*) thrive in extensive areas of Spain and Portugal with climatic conditions comparable to those where sudden oak death occurs in California. Since the foliage of an important number of understorey plants accompanying these trees has been shown to be susceptible *in vitro* to *P. ramorum* (Moralejo and others 2006a), and because this foliage is capable of sustaining sporulation (Moralejo and others 2006b), we consider that there is a high risk of the pathogen becoming established and provoking tree mortality in the Iberian Peninsula. At the local scale, our results highlight the risk posed especially to forest ecosystems in southern Spain (e.g. the Alcornocales Natural Park) where relict populations of *Q. canariensis* grow with *Rhododendron ponticum*, *Viburnum tinus* and other potential host species of the understorey.

Key words: Invasive alien species, oak woodlands, *Phytophthora hedraiaandra*, plant pathogen, trunk canker.

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