

PHYTOPHTHORA DISEASES OF OAK IN EUROPE

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Abstract

Decline and mortality of European oak ecosystems has been reported since the early 20th century. Among the various contributors to decline are species of *Phytophthora*, particularly *P. cinnamomi*, which is known to be involved in Iberian oak decline. However, recent investigations have shown there are a variety of other *Phytophthora* species associated with oak trees in Europe and Turkey.

Surveys of *Phytophthora* in oak forests in Europe and adjacent countries yielded a diverse assemblage of species including; *P. cinnamomi*, *P. cambivora*, *P. citricola*, *P. gonapodyides*, *P. megasperma*, *P. cactorum* and *P. cryptogea*. In addition, five new species were discovered; *P. quercina*, *P. europaea*, *P. uliginosa*, *P. psychrophila* and *P. pseudosyringae*, some other taxa await description. Some species occurred over a broad geographic area while others were isolated from specific locations. The two most common species were *P. quercina* followed by *P. citricola*.

Phytophthora species associated with oak trees probably require different site conditions to thrive in forest soils. The exotic pathogen *P. cinnamomi* was only recovered once in Turkey and never in Austria. In related studies, in Germany *P. cinnamomi* was not found but frequently was encountered in Italy and parts of France. Its recovery may indicate an existing climatic limit for the pathogen. Other *Phytophthora* species such as *P. gonapodyides* and *P. uliginosa* were encountered on sites where aquatic habitats and hydromorphic soils exist and *P. psychrophila* was associated to non-hydromorphic soils. *P. quercina* and *P. citricola* were isolated from sites with the greatest variation in site characteristics (e.g. soil type, soil moisture and pH). This may explain their wide distribution and frequent recovery over a wide geographic area. Noteworthy, *P. quercina* was recovered on very dry sites where *Phytophthoras* usually do not thrive.

Phytophthora species were more frequently recovered from rhizosphere of declining than healthy oak trees. Similarly, in Germany and Turkey a significant association existed between the presence of *Phytophthora* species and the decline status of oaks. In Italy *P. quercina* was the only species significantly associated with declining oak trees, whereas there was a mild evidence for connection between deteriorating crown status and the presence of *Phytophthora* spp. in Austria. Further, in Germany it was shown that the level of fine root damage was significantly higher in oaks infested with *Phytophthora* spp and particularly *P. quercina*. However, evidence obtained from forest conditions cannot be interpreted directly as a cause and effect relationship.

In various stem and root inoculation tests, *Phytophthoras* differed in their aggressiveness to oaks and in their host and tissue specification. The most frequently recovered species, *P. quercina* appear to be host specific and capable of causing fine root mortality of oak, but did not attacked the main bark of any host species tested. Most of the other recovered species were non-host specific while causing damage at different extent to their hosts. The order of aggressiveness among isolates as well as between the encountered species showed considerable variation on root inoculation and on stem inoculation tests. In soil infestation tests *Phytophthoras* were able to cause more damage on plants under stress condition (e.g. drought or flooding experiments).

Oak species differed in their susceptibility toward *Phytophthora* infection. Though, holm oak (*Q. ilex*) was much more susceptible to *P. cinnamomi* infection than any other oak species tested, where inoculated saplings displayed highest root loss and mortality. By contrast, pedunculate and red oak displayed low root susceptibility to *P. cinnamomi*.

The type of symptoms in *Phytophthora*-infected oak forests usually appears without mortality suggesting, at least for some species, a natural association. In addition to the surveys in throughout Europe, studies in Turkey revealed some evidence that the most common species

P. quercina is probably co-evolved with oak species occurring on a wide range of oak ecosystems including endemic forests. However, associated *Phytophthoras* could play a greater role under conducive soils and may cause more damage to their hosts under stress conditions.