Phytophthora plurivora **System:** Terrestrial

Kingdom	Phylum	Class	Order	Family
Chromista	Oomycota	Peronosporea	Peronosporales	Peronosporaceae

Common name

Synonym

Similar species

Summary

This species was described in 2009 and it has an uncertain origin. It is thought to potentially originate from South-East Asia and is considered as alien in Europe and North America. The oomycete is a very aggressive pathogen with a wide range of plant hosts. It has been implicated in the severe decline of multiple species throughout Europe and in North America, such as Oak and Beech. Its common presence in nurseries is thought to indicate an important route of introduction and is another impact of the species.

[view this species on IUCN Red List]

Species Description

Phytophthora plurivora is a fungus-like pathogen capable of infecting a very wide range of plant hosts. This oomycete was described in 2009 by Jung & Burgess as having the following characteristics: Its sporangia are typically borne terminally on unbranched sporangiophores, with the overall range of sporangial dimensions reported as 27.5–80.5 × 16.7–69.6µm. They are non-caducous, semipapillate or sometimes bi- or tripapillate, or bilobed. They usually form a conspicuous basal plug that protrudes into the empty sporangium. The shape of the sporangia is very variable, being ovoid, limoniform, obpyriform, ellipsoid or a distorted shape. Sporangia with unusual features are commonly found. These features can be lateral attachment of the sporangiophore, markedly curved apices, a widening of the sporangiophore towards the base of the sporangium or a short hyphal extension. The zoospores are discharged through an exit pore 5 to 10µm wide. Their shape ranges from limoniform to reniform when motile, and they become spherical, with a diameter of around 10µm, on encystment. The gametangia are readily produced in single culture. Oogonia are borne terminally, have smooth walls and are globose or subglobose. Older oogonia have walls that usually turn golden-yellow or golden-brown. These have a diameter of around 28.5µm. Oospores are usually globose and have a diameter of around 1.5µm. The antheridia are obovoid, club-shaped or irregular in shape, and sometimes have one or more fingerlike projections. They are almost exclusively paragynous and usually attach close to the oogonial stalk. Colonies grown on V8A or MEA produce limited aerial mycelium in the center and radiate to slightly chrysanthemum growth patterns. If grown on PDA, they have markedly more aerial mycelium than on other media. Colonies can produce globose, subglobose or appressoria-like hyphal swellings and dense, brush-like or coralloid clusters of lateral hyphae. The optimum growth temperature is 25oC, and the maximum temperature for growth is 32oC. At 25oC, the radial growth rates range from 8.0 to 8.4 mm/d. Lastly, this species is usually identified through sequencing of its ITS region, cox1 and beta-tubulin gene regions (Jung & Burgess 2009).

Notes

Taxonomy This species was previously considered as part of the P. citricola complex. It was described as its own species in 2009, and much of the literature referring to P. citricola before then has been considered as referring to P. plurivora (Jung & Burgess, 2009). Spread This species is very common in ornamental nurseries. They are an important route for its global spread. In nurseries, the pathogen can survive in water runoffs and reservoirs, plant debris in containers and in asymptomatic plants (Junker et al., 2016). The pathogen can spread via water if introduced into a river basin from nursery stock (Zamora-Ballesteros et al., 2017). Interactions Elevated CO2 levels have been shown to stimulate the activity and hence increase the impact of the species. This means that P. plurivora could become even more aggressive in the near future (Tkaczyk et al., 2014). Additionally, it has been shown that infected Quercus rubra leaves have increased levels of nitrogen and water content, which enhances the performance of L. dispar larvae feeding on them. This faster development of larvae means that they are exposed to natural enemies for a shorter period of time, increasing their impact as pests (Milanovic et al., 2015).

Lifecycle Stages

Oospores in the soil can germinate in warm temperatures and in the presence of water to produce sporangia. Mature sporangia release biflagellate zoospores, which are motile and can direct themselves to roots through chemotaxis. Once at a host root, they can germinate to produce hyphae, which grow into the plant cells. The pathogen spreads in this way through the host, until it forms sporangia in the root surface that can release more zoospores. Alternatively, it can form oospores that can persist under unfavorable conditions in the soil, even though they don’t form chlamydospores (Duares, 2015).

Habitat Description

This pathogen has a very wide host range. It has been known to infect 147 plant taxa, both dicotyledons and conifers (Jung et al., 2016). Among these are Acer platanoides, A. hippocastanum, A. glutinosa, A. incana, B. péndula, Carpinus betulus, F. sylvatica, P. aibes, P. sylvestris, Q. petraea, Q. robur, T. cordata, Viburnum lentago, Vaccinium myrtillus, V. uliginosum, and V. angustifolium (Blomquist, 2016; Rytkonen et al., 2012). It’s intolerant to pH levels below 3.5 and can frequently be found in silt loam and sandy loam soils with pH above 3.66 (Jankowiak et al., 2014; Jung et al., 2000). The vertical limit of its distribution in the Bavarian Alps was recorded as 870m a.s.l. (Jung & Burgess 2009).

Reproduction

P. plurivora is a homothallic species, meaning that it doesn’t outcross but can sexually reproduce through self-fertilization to produce oospores. It only has one mating type (Schoebel et al., 2014). The oospores can persist in the soil. It can also reproduce asexually through motile zoospores released from sporangia. These disperse in the water and can infect host roots.

General Impacts
Phytophthora plurivora is a major pathogen throughout Europe, as it can infect multiple taxa with high economic value. It also has impacts in North America and South-East Asian nurseries and plantations. Infections are very commonly found in nurseries, which causes economic loss through the mortality of trees. It's often isolated in nurseries from blighted ornamentals such as rhododendrons (Schoebel et al., 2014). In infected trees, the pathogen causes extensive fine root losses, bark necrosis, dieback, and thinning of foliage. Leaves can become abnormally small and yellowish. Necrosis in the inner bark can be seen as tarry or rusty spots on the bark, starting from the stem base. Death can occur within one or two years, or in some cases a few months if the plants are weak or young (Jung et al., 2005; Jung & Burgess, 2009). While these are symptoms common to the Phytophthora genus, P. plurivora has been described as one of the more aggressive members of the genus. Infected hosts become predisposed to damage by droughts and secondary pests such as C. fraxinea (Jung & Burgess 2009; Orlikowski et al., 2011). This pathogen has been involved in multiple devastating declines of forests across Europe and now in North America. European beech (Fagus sylvatica) stands in Europe and the USA have been showing increasing occurrences of symptomatic trees (Jung et al., 2005). It is also present extensively in European Oak stands (Jankowiak et al., 2014) and is thought to be a major contributor to the decline of alder (Zamora-Ballesteros et al., 2017). Because of its wide host range and aggressive symptoms, it has been referred to as the most threatening Phytophthora species (Duares, 2015).

Management Info
Because eliminating this pathogen once it's present is nearly impossible, management is usually centered around phytosanitary guidelines in nurseries (Blomquist, 2016). Infections occur mostly through spores in soil or zoospores in irrigation water, so these are good targets for preventing spread. Because plants can be asymptomatic even if infected, guidelines usually advise regular surveys of potential sources, such as puddles and other water sources. The pathogen has previously been managed with a number of fungicides, but resistance to some of these, such as metalaxyl, has developed (Joseph & Coffey, 1984; Hung et al., 2015). There are fungicides that have been developed specifically to prevent growth of Phytophthora species, such as mefenoxam and derivatives of phosphoric acid (Jung et al., 2005). Phosphites are an effective control agent that has proven to prevent mortality in infected plants, but it doesn't prevent the production of zoospores that can spread the disease further (Duares, 2015). Aluminium, calcium, and sodium tris-O-ethul phosphonates have been shown to inhibit sporangia development (Coffery & Joseph, 1985). Research on using Chaetomium spp. for biocontrol has shown that these species can slow the growth of multiple Phytophthora (Hung et al., 2015).

Pathway
P. plurivora is very commonly found in nurseries throughout all of Europe. Genetic analyses have determined that gene flow is unidirectional from Europe to the USA, suggesting that the pathogen arrived to North America through the plant trade.

Principal source: Durães, S. (2015). Pathogenicity tests of Phytophthora alni and Phytophthora plurivora in Fraxinus excelsior and Alnus glutinosa seedlings. Jung, T., & Burgess, T. I. (2009). Re-evaluation of Phytophthora citricola isolates from multiple woody hosts in Europe and North America reveals a new species, Phytophthora plurivora sp. nov. Persoonia, 22, 95. Jung, T., Hudler, G. W., Jensen-Tracy, S. L., Griffiths, H. M., Fleischmann, F., & Osswald, W. (2005). Involvement of Phytophthora species in the decline of European beech in Europe and the USA. Mycologist, 19(4), 159-166. Jung, T., Orlikowski, L., Henricot, B., Abad-Campos, P., Aday, A. G., Aguín Casal, O., ... & Corcobado, T. (2016). Widespread Phytophthora infestations in European nurseries put forest, semi-natural and horticultural ecosystems at high risk of Phytophthora diseases. Forest Pathology, 46(2), 134-163. Schoebel CN, Stewart J, Gruenwald NJ, Rigling D, Prospero S (2014) Population History and Pathways of Spread of the Plant Pathogen Phytophthora plurivora. PLoS ONE 9(1): e85368. doi:10.1371/journal.pone.0085368

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Red List assessed species 1: LC = 1;

Fagus sylvatica **LC**

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