CAPS Datasheets provide pest-specific information to support planning and completing early detection surveys.

Phytophthora alni species complex

Scientific Name

Phytophthora alni

Synonyms:

Phytophthora × *alni*
Phytophthora × *multiformis*
Phytophthora uniformis
Phytophthora alni ssp. *alni*
Phytophthora alni ssp. *multiformis*
Phytophthora alni ssp. *uniformis*

Common Name

Phytophthora disease of alder

Type of Pest

Fungal-like organism

Taxonomic Position

Class: Oomycetes, **Order:** Peronosporales, **Family:** Peronosporaceae

Notes on taxonomy

Phytophthora alni is a hybrid pathogen of alder (Brasier et al., 2004). Initially, three subspecies of *P. alni* were distinguished on the basis of morphological, cytological, and genetic features: *P. alni* subsp. *alni* (*Paa*), *P. alni* subsp. *uniformis* (*Pau*), and *P. alni* subsp. *multiformis* (*Pam*) (Brasier et al., 2004). Genetic analysis later proved that *Paa* is an allotriploid species, containing half the genomes of each parent taxa, i.e., *Pau* and *Pam*, which are diploid and allotetraploid, respectively (Husson et al., 2015). Therefore, the names *P.* × *alni*, *P. uniformis*, and *P.* × *multiformis* also have been used since 2015. Since that period, the term *P. alni* species complex, which includes the three above-mentioned taxa, has been broadly used in the literature (Trzewik et al., 2021) (**Note**: the name *P. alni* and abbreviations *Paa*, *Pau*, *Pam* will be used for the species complex and three subordinate taxa, respectively, in this document).

Phytophthora alni subsp*. alni* (*Paa*) appears to be the most aggressive and pathogenic to European alder species (Érsek and Nagy, 2008). *Paa* comprises about 89% of the European population of the complex (Brasier et al. 2004). The two other taxa (*Pau*, *Pam*) are less aggressive (Brasier and Kirk, 2001; Haque et al., 2015; Zamora-Ballesteros et al., 2016) and relatively rare in Europe, with the exception of *Pau* in Scandinavia (Redondo et al., 2015). *Pau* is common in streams and alder stands in

Figure 1. Alder plantation on former agricultural land; note infected grey alder (*A. incana*) with sparse, chlorotic, and small-sized foliage. Photo courtesy of T. Jung.

Alaska and Oregon without causing noticeable damage (Adams et al., 2010; Jung et al., 2018).

Pest Recognition

This section describes characteristics of the organism and symptoms that will help surveyors recognize possible infestations/infections in the field, select survey sites, and collect symptomatic material. For morphological descriptions, see the Identification/Diagnostic resources on the AMPS pest page on the CAPS Resource and Collaboration website.

Symptoms

Phytophthora alni causes a serious disease of alder, which has symptoms including root and collar necrosis, lower stem bark lesions, and crown dieback typical of other *Phytophthora* diseases (Gibbs et al. 1995; Gibbs et al., 1999). In riparian stands, the pathogen typically infects the tree through lenticels and roots at the collar and less frequently at the surface of exposed large roots. In a study of non-riparian sites, the pathogen often infects the tree through the tap roots, causing part of the root system beyond the observable collar rot to be dead (Jung and Blaschke, 2004). Infected plants in nurseries had no visible symptoms (Jung and Blaschke, 2004).

From a distance, diseased alders are notable in mid-to-late summer because the leaves are abnormally small, yellow, and sparse (Fig. 1, 2). Leaves often fall prematurely, leaving the branches bare. In a tree with severe crown symptoms, the lower part of the stem is often marked with a black or rusty colored exudate known as ‘tarry spots’ (Fig. 3) that can occur up to 6–10 feet from the ground. The spots indicate that the underlying bark is necrotic or dead (Gibbs et al., 2003; Thoirain et al., 2007). Tongue-shaped orange-brown necrosis of the inner bark is common (Fig. 3) (Gibbs et al., 1999). Over the next few years after infection, the fine twig structure, the bark, and eventually the trunk will break up. It is common for narrow strips of bark to remain alive and to support a limited growth of new shoots from the trunk and major branches (Webber et al., 2004). Adventitious roots may be seen on the stems of trees as a result of *Phytophthora* disease (Gibbs et al., 2003) (Fig. 4). Although not a specific symptom, the development of adventitious roots can be a useful indication of the presence of a bark lesion further down the stem. Early and often excessive fruiting with unusually small cones (Jung and Blaschke, 2004) and excessive seed production may occur (Redondo et al., 2015; Bjelke et al., 2016). Infected trees may survive for many years, and recovery may sometimes occur, especially when cold conditions suppress the pathogen (Jung et al., 2007a; Bjelke et al., 2016).

Figure 2. Mature common alder with collar rot caused by *P. alni* showing sparse, chlorotic, and small-sized foliage. Photo courtesy of T. Jung.

Easily Mistaken Species

Reliable diagnosis of *Paa* in the field is not possible; symptoms are similar to other root and collar rot *Phytophthora* species. Other *Phytophthora* spp. that are recorded on alder in Europe include: *P. plurivora*, *P. cactorum*, *P. gonapodyides*, *P. lacustris,* and *P. megasperma* (Streito, 2003; Jung and Blaschke, 2004; Nechwatal et al., 2013). Multiple *Pythium* spp. (another Oomycete) were also recorded from alder in Europe. However, *Paa* is the most common cause of collar lesions in alder in Europe, and isolation of other species in the epidemic phase of the disease is rare. Similar results were obtained in Alaska from 2007 and 2008 (Adams et al., 2010). A common fungal pathogen, *Valsa melanodiscus* (anamorph *Cytospora umbrina*), exhibits similar dieback symptoms as *P. alni,* and has been observed on alder in the southern Rocky Mountains, Alaska, Michigan, and Oregon (Worrall, 2009; Adams et al., 2010). Morphologically, the gametangia of *Paa* are similar to those of *P. cambivora*; however, the latter species is heterothallic (Brasier et al., 1999; Brasier et al., 2004; Jung and Blaschke, 2004).

Biology and Ecology

The biology of *P. alni* in the field is not well understood, but most species of *Phytophthora* infect their hosts mainly by motile spores (zoospores) that are dispersed through water and in the soil (Ioos et al., 2005; Trzewik et al., 2021). Infection of alder via zoospores in water could explain the high incidence of the disease on alder in

Figure 3. Left: Common alder (*A. glutinosa*) in a non-flooded forest plantation with root and collar rot (tarry spots) caused by *P. alni*. **Right:** Grey alder (*A. incana*) with collar rot caused by *P. alni*; note the typical tarry spots at the outer bark and the tongue-shaped orange-brown necrosis of the inner bark. Photos courtesy of T. Jung.

riparian zones, although the disease may also occur in sites away from waterways (orchard shelter belts and woodland plantations).

Optimum temperature of *P. alni* in culture is 73–77 °F with an upper temperature limit of about 86 °F (Brasier et al., 1995; Santini et al., 2001). The optimum temperature for lesion growth in inoculated *A. glutinosa* was 77 °F for all three subspecies of *P. alni* (Haque et al., 2015). In Sweden, the distribution of *Paa* and *Pau* is strongly correlated with winter conditions. Although it is more pathogenic to alder, *Paa* is less tolerant to cold winters and long periods of frost than *Pau*, which is found in colder climates (Redondo et al., 2015). In a study, *Paa* was absent from areas with an average winter temperature below -35 °F (Redondo et al., 2015). Schumacher (2006) also noted that in Germany, the activity of *Paa* is suppressed during the frost-rich months of December through March.

Known Hosts

Major hosts: *Alnus cordata* (Italian alder), *A. glutinosa* (European, black alder), *A. incana* (gray alder), and *A. viridis* (green alder) (Gibbs, 1995; Streito, 2003; Ioos et al., 2006; Santini et al., 2003).

Experimental hosts: *Alnus rubra* (red alder), *Castanea sativa* (chestnut), *Juglans regia* (walnut), and *Prunus avium* (sweet cherry) (Gibbs 1995, Santini et al., 2003; Santini et al., 2006).

Pest Importance

This pathogen complex mainly attacks the root neck of trees and causes the mass dying of alders in Europe (Černý and Strnadová, 2010; Lorenc and Samek, 2021). There are four alder species native to Europe: common alder (*A. glutinosa*), gray alder (*A. incana*), Italian alder (*A. cordata*), and green alder (*A. viridis*). All European alder species, some of which are also present in the United States, are susceptible to *Paa* (Downing et al., 2010). In general, members of the genus *Alnus* are pioneer species, able to colonize bare, open ground rapidly and can tolerate wet sites (Webber et al., 2004). Common alder has considerable landscape value along waterways and plays a vital role in riparian ecosystems, including stabilizing riverbanks (Webber et al., 2004).

Very high alder losses to *Paa* have occurred in some localities (parts of France and Germany); while in others the disease impact has been relatively small (Webber et al., 2004). In northeastern France, disease incidence has reached 17% in *A. glutinosa* (Thoirain et al., 2007). In southern Sweden, the average disease incidence of *P. alni* was 28% in a survey of numerous alder stands (Redondo et al., 2015). In a pathogenicity test, *Paa* caused mortality rates of around 30% of *A. glutinosa* seedlings in Spain (Zamora-Ballesteros et al., 2016). In a survey in southern Germany, *Paa* was found in 32% of surveyed alder stands (Jung and Blaschke, 2004).

The susceptibility of North American *Alnus* species is currently unknown, so it is difficult to assess the economic and ecological range of *Paa*. Cech (1998) reports that strains of *P. alni* were pathogenic to *A. rubra* (red alder), which is one of the few commercial hardwood species in the western United States (Cree, 2006). Heavy loss of alders due to *Phytophthora* infection could result in significant ecological effects including changes in forest and soil composition and wildlife food and habitat (Cree, 2006).

At the genus level, *Phytophthora* is listed as a harmful organism in the following countries: Canada, French Polynesia, Mexico, Namibia, Seychelles, South Africa, and Venezuela (USDA-PCIT, 2022). While *Pau* is established in Alaska and Oregon (Adams et al., 2008; Adams et al., 2010; Aguayo et al., 2013), there may be trade implications with these countries if *Paa* becomes established in other states.

Known Vectors (or associated insects)

P. alni is not a known vector, is not known to be vectored, and does not have any associated organisms.

Known Distribution

Europe: ***Paa***: Austria, Belgium, Czech Republic, Estonia, France, Germany, Hungary, Ireland, Italy, Lithuania, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, and United Kingdom (UK); ***Pau***: Austria, Belgium, Denkark, Czech Republic, France, Germany, Hungary, Italy, Lithuania, Norway, Slovenia, Spain, Sweden; ***Pam***: Belgium, France, Germany, Lithuania, Netherlands, Sweden, UK (Gibbs, 1995; Santini et al., 2001; Szabó et al., 2000; Streito et al., 2002; Brasier et al., 2004; Oszako and Orlikowski, 2005; CABI/EPPO, 2008; Cerny et al., 2008; Solla et al., 2010; Pintos Varela et al., 2010; Bjelke et al., 2016; Kanoun-Boule et al., 2016; EPPO, 2021; CABI, 2022).

North America: ***Pau***: Alaska and Oregon (Adams et al., 2008; Sims et al., 2012; Aguayo et al., 2013).

Note: The European distribution is predominantly *Paa*.

Pathway

Paa has spread throughout Europe via planting of infested nursery stock and irrigation of fields with infected river water (Jung and Blaschke, 2004). Once introduced, swimming zoospores spread naturally with streams, floods, and other drainage water (Bjelke et al., 2016). The pathogen may also be transported via movement of cattle between river systems (Redondo et al., 2015) and by fish farming (Jung and Blaschke, 2004). Cech (2013) hypothesized that *Pau* may have been introduced to Europe from North America on imported fish stock for hatcheries.

The most likely pathway of entry for *Paa* into the United States is through transport of contaminated soil, nursery stock, or wood with bark (Santini et al., 2003; Jung and Blaschke, 2004; Cree, 2006). Currently, the import of *Alnus* spp. plant material (except seed) is prohibited from all countries except Canada specifically to prevent the introduction of *Paa* (USDA, 2017).

Use the PPQ Commodity Import and Export manuals listed below to determine 1) if host plants or material are allowed to enter the United States from countries where the organism is present and 2) what phytosanitary measures (e.g., inspections, phytosanitary certificates, post entry quarantines, mandatory treatments) are in use. These manuals are updated regularly.

Agricultural Commodity Import Requirements (ACIR) database: ACIR provides a single source to search for and retrieve entry requirements for imported commodities. https://acir.aphis.usda.gov/s/

Plants for Planting Manual: This manual is a resource for regulating imported plants or plant parts for propagation, including buds, bulbs, corms, cuttings, layers, pollen, scions, seeds, tissue, tubers, and like structures.
https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/plants_for_planting.pdf

Treatment Manual: This manual provides information about treatments applied to imported and domestic commodities to limit the movement of agricultural pests into or within the United States.
https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf

Potential Distribution within the United States

Jung (2007b) and Downing (2010) developed a model to predict the potential distribution of *P. alni* in Bavaria, Germany and assess the potential hazard posted by *P. alni* to forests in other regions of the globe. Results indicate that much of the United States is vulnerable to the pathogen*. Pau* was found in Alaska on *Alnus incana* ssp. *tenuifolia* in 2007 (Adams et al., 2008; Adams et al., 2010). *Pau* has also been found on root tissue of symptomatic alder in Oregon (Sims et al., 2012; Sims et al., 2015). A genetic analysis study of *Pau* suggests that it is indigenous to the colder regions of North America such as Alaska and Oregon (Aguayo et al., 2013).

The Bavarian model also calculated the global susceptibility for *Paa*, the variant of concern to the United States, and included the United States as a suitable place where *Paa* could survive (Downing et al., 2010). Numerous species of alder, including several known hosts of *P. alni*, are present throughout the United States. *Alnus incana* is widespread in western states, the upper midwest, and northeastern states (BONAP, 2022). In addition, *A. viridis* is present in the upper Midwest and in the New England area (BONAP, 2022).

Survey

Approved Methods for Pest Surveillance:

For currently approved methods and guidance for survey and identification, see Approved Methods for Pest Surveillance (AMPS) pest page on the CAPS Resource and Collaboration website, at https://caps.ceris.purdue.edu/approved-methods.

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