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

Globodera pallida

Scientific Name
Globodera pallida (Stone, 1973) Behrens, 1975

Synonym(s):
Heterodera pallida Stone, 1973

Common Name
Pale cyst nematode, Pale potato cyst nematode, white potato cyst nematode

Type of Pest
Nematode

Figure 1. White females of *Globodera pallida* on root tissue (Photo courtesy of Dr. Louise-Marie Dandurand,

Taxonomic Position
Class: Chromadorea, **Order:** Rhabditida, **Family:** Heteroderidae (Price et al., 2021)

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.

Pest Description

Globodera pallida mature females and cysts (toughened cuticles derived from dead females, containing hundreds of eggs) are just visible to the naked eye and can be seen as tiny globes (0.58 mm long by 0.54 mm wide) on the host root (Figs. 1 and 3) (CERIS, 2023; Handoo et al., 2012). Young females are creamy white and as they mature into cysts (dead females), they change from white to brown (Fig. 3) (Wainer and Dinh, 2021).

Symptoms

Globodera pallida can cause patches of poor growth within a field, and plants in these patches may exhibit yellowing, wilting, and stunting (Fig. 2) (Betancourth et al., 2021; CERIS, 2023; Contina et al., 2020; Vovlas, 1996). Affected plants may suffer yield loss with smaller tubers (Fig. 4) (Haverkort et al., 1993; Schans and Arntzen, 1991). Rarely, potato tubers can also be infested (Fig. 5) (Vovlas, 1996).

Infested potato plants may have a reduced root system leading to water stress and reduced nutrient uptake (de Ruijter and Haverkort, 1999; Evans, 1982; Trudgill, 1986). Therefore, symptoms may be mistaken for simple nutrient deficiency or other environmental stressors (Augustin, 2022).

Figure 2. Patches of poor potato growth in a field due to potato cyst nematode infestation (Photo courtesy of Dr. Louise-Marie Dandurand, University of Idaho)

Affected tomato plants exhibit slow growth, areas of root swelling, and yield loss (Vovlas et al., 1986; Whitehead et al., 1979).

Easily Mistaken Species

This species can be confused with other *Globodera* species, particularly *G. rostochiensis, G. tabacum,* and *G. ellingtonae*. *Globodera rostochiensis,* a serious pest of potato, has been introduced to the United States and is under official control in parts of New York (USDA-APHIS-PPQ, 2022a). *Globodera tabacum*, which occurs in the United States, primarily infests tobacco and can rarely reproduce on potato (Skantar et al., 2007). *Globodera ellingtonae* has been reported to infest potato in Idaho and Oregon (Handoo et al., 2012); however it is not known to cause the severe yield loss in potato that has been observed with *G. pallida* and *G. rostochiensis* (Zasada et al., 2019).

Figure 3. Comparison of *Globodera rostochiensis* (top) and *Globodera pallida* (bottom). Females of *G. pallida* turn from white/cream directly to brown cysts whereas *G. rostochiensis* females change from white to yellow/gold before they turn brown. (Photo courtesy of Ulrich Zunke, University of Hamburg, http://www.bugwood.org/, CC BY-NC 3.0)

Figure 4. Left: Potatoes grown in soil without potato cyst nematodes; Right: Small potatoes as a result of growing in soil with potato cyst nematodes (Photo courtesy of Dr. Louise-Marie Dandurand, University of Idaho)

Globodera pallida and *G. rostochiensis* can be differentiated from each other if the female is at the appropriate stage. As *G. rostochiensis* females mature and die, becoming cysts, they turn from white to yellow/gold and then brown, whereas *G. pallida* changes directly from white to brown (Fig. 3) (Baldwin and Mundo-Ocampo, 1991). Otherwise, distinguishing between *Globodera* species will require detailed morphological or DNA-based analysis. Morphological characters and keys to differentiate between these species can be found in various publications (Baldwin and Mundo-Ocampo, 1991; Golden and Ellington, 1972; Handoo et al., 2012; Lax et al., 2014; Mulvey and Golden, 1983; Spears, 1968; Subbotin et al., 2010). PCR assays have been developed to detect and distinguish between *Globodera* species (Madani et al., 2005; Madani et al., 2008; Nakhla et al., 2008; Nakhla et al., 2010; Pylypenko et al., 2005; Skantar et al., 2007; Yu et al., 2011).

Commonly Encountered Non-targets

The approved survey method is to either take soil samples (the preferred method) or root tissue samples from potentially infested fields. The most commonly encountered non-targets using the approved survey methods are other *Globodera* species, primarily the easily mistaken species listed in the previous section (Baldwin and Mundo-Ocampo, 1991; CERIS, 2023; Handoo et al., 2012).

Biology and Ecology

Globodera pallida overwinters as eggs inside the cyst. Each cyst contains 200 to 500 eggs (Fig. 6) (Evans and Stone, 1977; Lettice and Jones, 2016). Second stage juveniles (J2s) hatch rapidly after plant emergence, peaking between two to five weeks after emergence (Devine and Jones, 2003; Ryan and Devine, 2005). Optimum hatching temperature ranges from 55 to 77°F (Kaczmarek et al., 2014). J2s move short distances (a few inches, possibly as much as 1 foot) through the soil searching for host roots, which they penetrate, move through, and feed on (Baldwin and Mundo-Ocampo, 1991; Picard et al., 2004). They undergo three molts before reaching the adult stage, with the life cycle taking approximately 9 weeks to complete (Kaczmarek et al., 2019; Price et al., 2021).

Females establish a permanent feeding site in the root, where they become sedentary (Baldwin and Mundo-Ocampo, 1991). Females enlarge and eventually burst through the root, exposing their tail end to the soil. The males, who are motile and do not feed, exit the root and travel through the soil to mate with the exposed females (Baldwin and Mundo-Ocampo, 1991; Price et al., 2021; Wainer and Dinh, 2021). The females retain the fertilized eggs within their bodies, and when they die, they become cysts (Baldwin and Mundo-Ocampo, 1991; Evans and Stone, 1977; Jones et al., 2017). Cysts eventually detach from the root and remain in the soil (Evans and Stone, 1977).

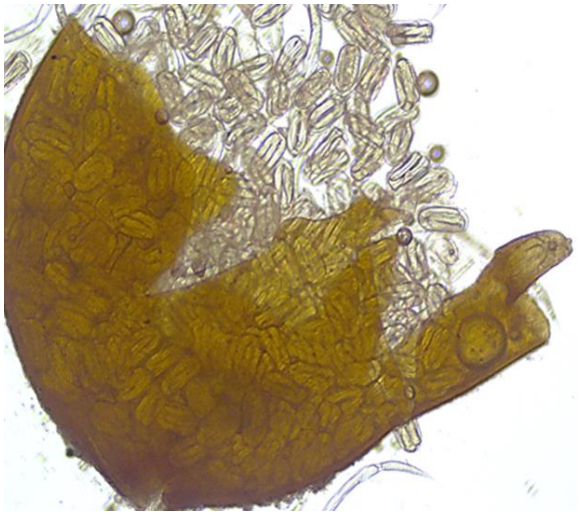

Figure 6. Cyst of *Globodera pallida* containing hundreds of eggs. (Photo courtesy of Dr. Louise-Marie Dandurand, University of Idaho)

Globodera pallida generally has one generation per year and it persists in the soil as a dormant stage (diapaused, embryonated eggs in a cyst) for up to 30 years (Ebrahimi et al., 2014; Fournet et al., 2018; Turner, 1996). There are three recognized pathotypes of *G. pallida* (Pa1, Pa2, and Pa3), which are characterized by their ability to reproduce on *Solanum* host plants with different genes for resistance (Gartner et al., 2021; Kort et al., 1977).

Known Hosts

The most important agricultural host of *G. pallida* is *Solanum tuberosum* (potato) (Bhattarai et al., 2009), though it also infects *S. lycopersicum* (tomato) (Whitehead et al., 1979).

The host list below includes cultivated and wild plants that 1) are infected or infested by the pest under natural conditions, 2) are frequently described as major, primary, or preferred hosts, and 3) have primary evidence for feeding and damage documented in the literature. Plants are highlighted in bold if they are commercially produced and the pest causes economically significant damage.

Preferred hosts
***Solanum tuberosum* (potato)* (Greco et al., 1993)**

Other members of Solanaceae can allow multiplication of *G. pallida* and may be found as weeds in agricultural fields (Baldwin and Mundo-Ocampo, 1991; Boydston et al., 2010). These may be a target for survey.

* Hosts with known U.S. distribution

Pest Importance

The pale cyst nematode, *G. pallida*, is considered one of the most important nematode pests of potato where it occurs (Širca et al., 2012). Yield loss caused by *G. pallida* is closely related to the number of nematode eggs in the soil, as well as the potato cultivar and soil type (Evans, 1993; Greco et al., 1982; Schouten and Beniers, 1997). Yields may be reduced even when no apparent symptoms are seen aboveground (Sudha et al., 2016). Yield losses can be very high where soils are heavily infested, and in some cases, potato yields may be lower than the seed tubers planted (Evans, 1993; Mai, 1977). Twining et al. (2009) reports that 4% of potato yield for processing and fresh market has been lost annually in the United Kingdom, resulting in losses of £26 million per year. In Kenya, potato yield losses due to cyst nematodes were estimated at $127 million annually in 2016 and 2017 (Mburu et al., 2020).

Globodera pallida poses a serious threat to American domestic and international trade in potatoes and any agricultural commodity shipped from the regulated areas that carries soil, such as nursery, turf, root, and tuber crops (Dandurand et al., 2019; Koirala et al., 2020; Prasad, 2008). Approximately 20 percent of potatoes grown in the United

States are exported, with a value of $1.88 billion in 2021 (Knudson and Miller, 2023). Some of the largest export markets of U.S. potatoes that consider *G. pallida* a quarantine pest are Canada, Mexico, Japan, and South Korea (Dandurand et al., 2019; Knudson and Miller, 2023). The National Potato Council estimates that farm production of potatoes was valued at $10.8 billion in 2021 (Knudson and Miller, 2023).

Globodera pallida is a PPQ program pest and is under official control with regulations to prevent its spread (USDA-APHIS-PPQ, 2022b) and is considered a pest of concern on the EPPO A2 list (EPPO, 2022).

Known Vectors (or associated insects)

Globodera pallida is not a known vector, nor is it known to be vectored. This species was recently shown to be associated with an RNA virus, but it is unknown if the virus has any impact on the nematode (Ruark et al., 2018). Injury from nematode feeding can increase disease severity caused by soilborne fungi such as *Rhizoctonia solani* and *Verticillium dahliae* (Bhattarai et al., 2009; Evans, 1987; Storey and Evans, 1987).

Known Distribution

Globodera pallida is likely native to the Andean mountains and has spread to many potato-growing regions globally (Plantard et al., 2008).

Africa: Algeria, Kenya, Morocco, and Tunisia; **Asia:** India, Japan, and Pakistan; **Central America:** Costa Rica and Panama; **Europe:** Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Luxembourg, Malta, Netherlands, Norway, Portugal, Romania, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom; **Middle East:** Lebanon; **North America:** Canada, United States (Idaho); **Oceania:** New Zealand; **South America:** Argentina, Bolivia, Chile, Colombia, Ecuador, Falkland Islands, Peru, and Venezuela (Bakker et al., 1992; Bendezu et al., 1998; Casanova et al., 2012; da Cunha et al., 2012; de Scurrah and Franco, 1985; Douda et al., 2012; EPPO, 2000, 2011, 2018a, 2018b, 2019, 2020, 2023a, 2023b; Evans et al., 1975; Farnier et al., 2012; García et al., 2009; Grubisjc et al., 2013; Hajjaji et al., 2021; Hlaoua et al., 2008; Jakobsen, 1973; Kachacha et al., 2020; Koleva et al., 2017; Lay et al., 1980; Madani et al., 2010; Marks and Rojancovski, 1998; Marshall, 1993; Martinez-Beringola et al., 1987; Mburu et al., 2018; Narabu et al., 2016; Nježić et al., 2013; Palkovics, 2003; Plantard et al., 2008; Seenivasan, 2017; Shahina and Erum, 2007; Širca et al., 2012; Skantar et al., 2007; Tirchi et al., 2016; Vallejo et al., 2021; van Riel and Mulder, 1998; Vovlas and Grammatikaki, 1989; Zaheer et al., 1992; Zasada and Gatt, 2000).

There are also miscellaneous records from Philippines, Sierra Leone, and Sri Lanka, but these could not be verified.

Status of infestation in the United States (July 2024)

Globodera pallida was found in 2006 in a small area of northern Bingham and southern Bonneville counties in Idaho (Hafez et al., 2007; USDA-APHIS-PPQ, 2010). *Globodera*

pallida has been successfully controlled and contained to these counties, where it remains under official control (USDA-APHIS-PPQ, 2023). After the initial detection of *G. pallida* in the United States in 2006, Canada, Mexico, and South Korea cut off importation of potatoes from Idaho, while Japan cut off importation of potatoes from the entire United States (Dandurand et al., 2019). Because of extensive field surveys throughout Idaho, all of which have been negative outside of the regulated areas, these countries have resumed importation of potatoes from counties not under official control (USDA-APHIS-PPQ, 2023).

Pathway

The spread of potato cyst nematodes (*G. pallida* and *G. rostochiensis*) via active dispersal is not a concern because the J2s cannot move long distances in the soil. Although exact dispersal distances have not been measured, nematodes move only in the water phase of soil and therefore, dispersal is thought to be limited to between an inch and a foot (Picard et al., 2004). However, all life stages can be dispersed passively via contaminated agricultural tools, workers, animals, wind, soil, irrigation water, and propagative material (Picard et al., 2004; Schomaker and Been, 1999). Cysts containing viable eggs of *G. pallida* can persist in infested soil for nearly 30 years (Turner, 1996).

It is thought that potato cyst nematodes were introduced into Europe along with potato tubers from South America. From Europe, they were further spread to potato-growing regions around the world through infested seed pieces and contaminated machinery (Baldwin and Mundo-Ocampo, 1991; Brodie and Mai, 1989).

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) manual: 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

Based on where *G. pallida* is known to occur in the world and comparing those climates with Global Plant Hardiness Zones, we expect that *G. pallida* could establish in plant hardiness zones 4-13 (Lay et al., 1980; Madani et al., 2010; Takeuchi et al., 2018). As of 2023 in the United States, *Globodera pallida* is only found in in a small area of northern Bingham and southern Bonneville counties in Idaho (Dandurand et al., 2019; Hafez et al., 2007; USDA-APHIS-PPQ, 2010). It is not considered widely present nor distributed throughout the United States (USDA-APHIS-PPQ, 2023).

Large scale potato producing states are most likely to be impacted by *G. pallida*. The states with the most potato production as measured in US dollars are as follows: Idaho, Washington, Wisconsin, Colorado, California, North Dakota, Oregon, Maine, Minnesota, Michigan, Nebraska, Florida, and Texas (NASS, 2023). However, potatoes are cultivated in every state, and there are known experimental hosts of *G. pallida* throughout the United States, so this nematode could possibly establish in any state.

Survey and Key Diagnostics

Approved Methods for Pest Surveillance*:

For the current 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://approvedmethods.ceris.purdue.edu/.

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Versions

September 2023 (Version 3):

- Converted to new template with comprehensive revision of all sections. Updated class and order in **Taxonomic Position**.
- Changed references to cite available primary data and reworded information accordingly.
- Reduced technical language.
- Added Estonia, Kenya, Latvia, and Morocco to **Known Distribution** and removed Iran and Poland.
- Updated statistics and information throughout the document where applicable.

November 2016 (Version 2.1): Added Japan to distribution

July 2014 (Version 2): Added additional references that were recommended by Andrea Skantar. Updated the Key Diagnostic and Easily Confused Species sections to reflect these new references.

Version 1 was completed at an unknown date.

Reviewers

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