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

Synchytrium endobioticum

Scientific Name

Synchytrium endobioticum (Schilbersky) Percival

Synonyms:

Chrysophlyctis endobioticum Schilb.
Synchytrium solani Massee

Common Name

Disease: potato wart disease, cauliflower disease, warty disease

Fungus: black scab, black wart, potato cancer, potato canker, potato tumor, potato wart

Figure 1. Potato tuber covered in galls Image credit to Her Majesty the Queen in Right of Canada (Canadian Food Inspection Agency, 2012).

Type of Pest

Fungus

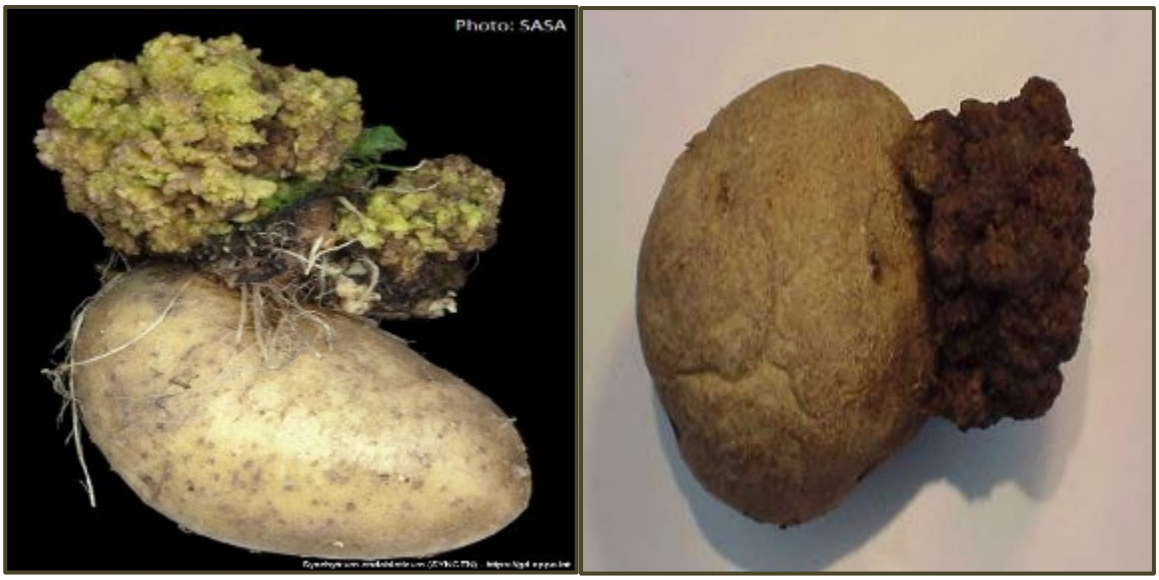
Taxonomic Position

Class: Chytridiomycetes, **Order:** Chytridiales, **Family:** Synchytriaceae

Pest Recognition

The main diagnostic symptom of potato wart disease is galls on plant parts belowground (i.e., stolon bud, stem base, and tuber eyes). Young developing tubers infected with *S. endobioticum* can be spongy and distorted. Tubers may be mangled or entirely replaced by galls (Fig. 1) (Stevenson et al., 2001). Sprouts can also be so severely infected that the potato plant fails to develop from planted tubers (Hampson, 1993). Galls rarely form on aboveground plant parts such as leaves, flowers, and upper stems and do not form on roots (Hampson and Coombes, 1985; Stevenson et al., 2001).

Initially, galls are white to brown when formed underground or in storage. If the galls are exposed to light, they will turn green (Fig. 2a). At maturity, the galls turn black and eventually decay (Putnam and Sindermann, 1994; Stevenson et al., 2001) (Fig. 2b). The galls are soft and pulpy in texture, with a surface that is rough and ribbed, giving it



Figures 2a and 2b. a) Potato tuber with fresh galls (image credit to Science and Advice for Scottish Agriculture (SASA); b) tuber with mature darkened galls https://extension.umaine.edu/publications/2445e/

the wart-like appearance. They are mostly round and measure on average between 0.40 to 3.20 inches in diameter (Stevenson et al., 2001). Galls in decaying tissues contain resting sporangia (structure containing mobile spores) (Fig. 3).

Easily Mistaken Species

Potato wart symptoms can be confused with other potato diseases. Powdery scab (causal agent: *Spongospora subterranea*) (Fig. 4) is soilborne, affects stems and stolons, and causes wart-like galls on tubers (Merz, 2008). Potato smut (causal agent: *Thecaphora solani*) is characterized by wart-like swellings on the surface of potato tubers (Fig. 5) (Chalkley, 2016). Both of these pathogens occur in the United States (Farr and Rossman, 2022). Potato wart can also be confused with proliferation of eyes known as “false wart” or “pseudo wart” (Fig. 6). It is not clear what causes this symptom, but it may be physiological or varietal and stimulated by chemical treatment of tubers (EPPO, 2017; Franc, 2007).

Biology and Ecology

Resting spores are released into the soil from decaying warts. Under favorable conditions (adequate water supply (700-800 mm) and soil temperatures (ranging from 62-64°F) for potato wart infection, the resting spore releases 200 to 300 mobile spores (Bojňanský, 1960; Hartman, 1955). The mobile spore swims through the soil water profile to a host and enters the host cell. The host cell enlarges and encompasses the mobile spore. The mobile spore repeatedly divides and produces more mobile spores.

The enlarged host cell ruptures, releasing the new mobile spores. The mobile spores can repetitively reinfect the surrounding host cells. Under stressful conditions such as water stress, the mobile spores fuse in pairs to form a zygote (Curtis, 1921). The zygote invades the host cell and the host cell divides. The zygote, now known as a resting

sporangium, moves deeper into the host tissue. Unlike the proliferation caused by mobile spore infection, tissue containing only resting sporangia remains smooth on the surface. The host cell wall forms the outer layer of the thick-walled, long-lived resting sporangium, about 50µm in diameter (Fig. 3). The resting sporangium are released into the soil from rotting warts (Noble and Glynne, 1970).

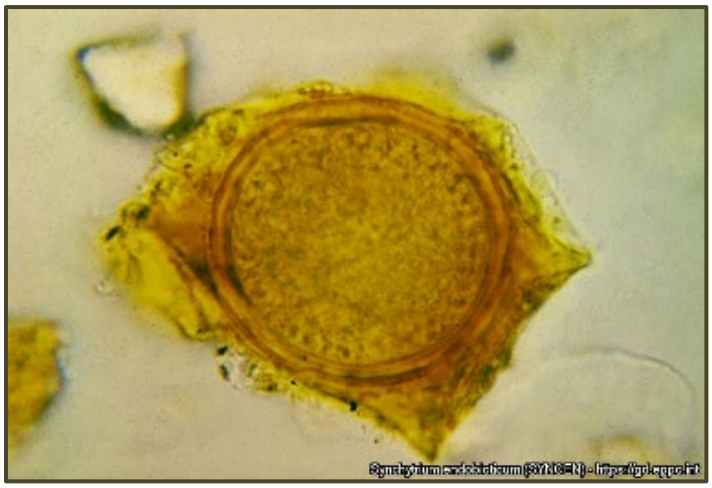


Figure 3. Live resting (winter) sporangium of *Synchytrium endobioticum.* Image courtesy of Central Science Laboratory, York (GB) British Crown.

Known Hosts

Of cultivated plants, *S. endobioticum* is known only to infect potato, *Solanum tuberosum,* under natural conditions. *Solanum tuberosum* is commercially cultivated in at least 20 U.S. states (BONAP, 2022; USDA-NRCS, 2022). *Synchytrium endobioticum* also infects wild potatoes, including *S. stoloniferum* and *S. vallis-mexici*. (Niederhauser, 1953). *Solanum lycopersicum* L. (tomato) has been reported as a host, but there is no evidence of tomato being naturally infected by potato wart in the field (Hampson, 1979; Lyman et al., 1920).

Pest Importance

Synchytrium endobioticum is soilborne and can spread long distances by the movement of infected propagative material and infested soil (Hampson, 1993). *Synchytrium endobioticum* can remain dormant for more than 30 years and has narrow environmental parameters for disease expression (Arora and Khurana, 2004; Laidlaw, 1985). This pathogen can cause yield losses up to 100 percent (Hampson, 1993; Mel'nik and Malakhanova, 1998).

Recent detections of *S. endobioticum* on Prince Edward Island, Canada, have caused significant trade issues for the province. After the detections, Canada halted potato exports from this major potato producing area into the United States (USDA, 2021). Detections of *S. endobioticum* in the United States may impact trade, since many countries regulate it as a quarantine pest (Baayen et al., 2005).
The European and Mediterranean Plant Protection Organization (EPPO) has designated *S. endobioticum* as an A2 pest, which is a quarantine pest present in the EPPO region. Ninety-nine countries consider *S. endobioticum* a harmful organism (PExD, 2022). *Synchytrium endobioticum* is considered a Select Agent for the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS-PPQ, 2022b) because it poses a severe risk to plant health (USDA-APHIS-PPQ, 2022b).

Figure 4. *Spongospora subterrana*, powdery scab. Image courtesy of https://www.germicopa.com/en/.

Figure 5: Potato smut (*Thecaphora solani*) Barrus on potato (*Solanum tuberosum* L.. Image by William M. Brown Jr., Bugwood.org

Known Vectors (or associated insects)

This species is known to be neither a vector, be vectored or have any associated organisms.

Figure 6. Pseudo-warts (courtesy ILVO, BE).

Known Distribution

This species is possibly native to the following countries:
South America: Bolivia, Chile, Ecuador, Falkland Islands, and Peru (Hampson, 1993).

This species has been introduced and is most likely established in the following countries:

Africa: South Africa and Tunisia**; Asia:** Armenia, Bhutan, India, Nepal, Turkey, and Russia; **Europe:** Belarus, Bulgaria, Czech Republic, Denmark, Faroe Islands, Finland, Germany, Georgia, Italy, Luxembourg, Montenegro, the Netherlands, Norway, Poland, Romania, Russia, Slovakia, Sweden, Ukraine, and the United Kingdom (Scotland); **North America**: Canada (Newfoundland and Prince Edward Island); **Oceania**: New Zealand (EPPO, n.d.; Çakir, 2005; De Boer, 2001; Basim et al., 2005; Dimitrova et al., 2011; CFIA, 2012; Gorgiladze et al., 2014; IPPC, 2014).

Synchytrium endobioticum has been eradicated in the United States (Maryland, Pennsylvania, and West Virginia) (Putnam and Sindermann, 1994). *Synchytrium endobioticum* has also been eradicated from Austria, Chile, France, Hungary, Latvia, Lithuania, Northern Ireland, Portugal, Slovenia, and Switzerland (EPPO, 2014; EPPO,

2021). Small outbreaks of *S. endobioticum* have occurred in Novia Scotia and Labrador North Shore in 1941 and 1957, respectively (Conners, 1942; Hampson, 1993).

There are also invalid and unreliable records on potato wart in Algeria, Egypt, Iran, Korea, Lebanon, Philippines, Syria, Taiwan, and Zimbabwe (EPPO, 2021).

Pathway

Humans are responsible for long-distance dispersal of *S. endobioticum* through movement and trade of infected potato tubers or tubers contaminated with infested soil (Obidiegwu et al., 2014). Humans also spread the pathogen by moving infested soil on farm machinery, equipment and tools, and footwear (Hampson et al., 1996; Hampson and Coombes, 1989; Obidiegwu et al., 2014). Other ways *S. endobioticum* can spread long distances include: 1) manure from animals that have ingested infected tubers, 2) infested soil on animals' hooves, 3) runoff of contaminated irrigation water, and 4) windblown dust from infested fields (Hampson, 1981, Hampson, 1996; Hampson and Coombes, 1989; Joestring, 1990; Obidiegwu et al., 2014).

On its own, *S. endobioticum* can swim a distance of up to 2 inches (Franc, 2007; Weiss, 1925). These mobile spores remain viable in the soil for a maximum of 2 hours after forming, depending on temperature (Curtis, 1921; Franc, 2007; Percival, 1910). Earthworms may disseminate *S. endobioticum* over a small area (4 to 10 inches) (Hampson and Coombes, 1989).

The United States regulates *S. tuberosum* tubers from countries where *S. endobioticum* is known to occur (USDA-APHIS-PPQ, 2022b; USDA-APHIS-PPQ, 2022a). All imported potatoes are subject to inspection (7 CFR 319.56-3). The inspector may suggest disinfection at the first port of arrival and reinspection at other locations. Seed potatoes for planting are currently not allowed into the United States from Prince Edward Island. Commercial shipments of potatoes for consumption from Prince Edward Island require a phytosanitary certificate with additional declarations (USDA-APHIS-PPQ, 2022a; PPQ, 2022).

Potential Distribution within the United States

Potato is grown either commercially or in home gardens throughout the United States (USDA-NASS, 2020b; USDA-NASS, 2020a USDA-NRCS, 2022), and some of these areas are climatically suitable for potato wart establishment. Areas climatically suitable for potato wart establishment have the following three climate parameters:

- Annual precipitation greater than 700 mm (Bojňanský, 1960);
- At least 160 days with a minimum temperature of 41°F or below (Bojňanský, 1960); and,
- Average air temperatures between 50.2 and 75.6°F during the growing season for one month or more (Bojňanský, 1960; Weiss, 1925).

Climatic suitability was calculated based on the occurrence of these three environmental parameters in the same area over a 20-year period (2000-2019). If one or more parameters did not meet the climatic requirements, then the likelihood for that area became zero and the area was considered unsuitable. The climate suitability maps can be found **here**.

The most suitable areas for the establishment of potato wart in the United States are in the northeast (Connecticut, Delaware, Maryland, Massachusetts, Maine, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont), parts of the Midwest (Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Ohio, and Wisconsin), and limited areas of the Pacific region (California, Oregon, and Washington).

Survey and Key Diagnostics

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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Versions

April, 2013: Version 1 completed
August 2022: Version 2, comprehensive update of entire datasheet

Reviewer(s)

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