cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Synchytrium endobioticum (Schilb.) Percival 1909

Potato Wart

Current Pest Rating: none

Proposed Pest Rating: A

Domain: Eukaryota; Kingdom: Fungi;
Phylum: Chytridiomycota; Class: Chytridiomycetes;
Order: Chytridiales; Family: Synchytriaceae

Comment Period: 09/24/2021 through 11/08/2021

Initiating Event:

This pathogen has not been through the pest rating process. The risk to California from *Synchytrium endobioticum* is described herein and a permanent pest rating is proposed.

History & Status:

Background: Potato wart disease, caused by the most important world-wide quarantine pathogen of potato *Synchytrium endobioticum*, causes tumors on the host tissue that can result in yield losses between 50-100%. It is on the United States Select Agent list of pests capable of considerable economic damage to agricultural crops but is not established in the United States (known only from incursions that were eradicated). Potato wart causes dramatic disease symptoms with tumor-like galls or warts on tubers and underground portions of potato stems. These deformities make the potatoes unmarketable and reduce yield. The resting spores of the pathogen can remain viable in field soil for 40 years or more, effectively eliminating infested fields from commercial potato production forever.

This pathogen likely originated with potatoes in the Andes mountains of South America. It was introduced from there into the England and to continental Europe in the 1880s. One of the earliest formal descriptions of potato wart and the pathogen (by Schilbersky) is from Hungary in 1896. In 1900s, potato wart was reported from Ireland, Scotland, Wales, and Germany. It gradually spread into other potato-growing regions of Europe until the 1940s. The first report of potato wart from North America was in 1909 in Newfoundland, Canada. The Federal Horticulture Board (United States)

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enacted a strict embargo of potatoes coming from countries where potato wart was known to occur (Kunkel, 1919). This embargo was not enacted in time to prevent introduction. Poor potato harvests in the U.S. during 1911 and 1912 lead to the importation of millions of pounds of tubers from Europe where potato wart was established. In 1918 potato wart was discovered in Pennsylvania, soon after in West Virginia, and, in 1920, the disease was found in Maryland (Lyman et al., 1920).

Regulatory actions have resulted in successful eradication of the pathogen from the United States; however, it took 70 years (Putnam and Hampson, 1989). Potato wart is still present in Canada, with detections in Prince Edward Island as recently as November 2020 (IPPC, 2020). Should there be a new detection, the quarantine area would include all positive fields and any fields that have come in contact with infected crop residue, seed, or infested soil. Movement of potentially infected host materials and potentially infested soil on equipment should be limited within and not allowed out of the quarantine area. All potato crops growing in the quarantine area must be destroyed using glyphosate or a similar herbicide at the labeled rate including all remaining potatoes and plant parts. All dead plant material must be burned in place, removed, double bagged, and sent to an approved landfill. Planting any hosts or potential hosts would be prohibited and ongoing surveys would eradicate any volunteer potatoes (USDA New Pest Response Guidelines, 2020).

Synchytrium endobioticum is an obligate, endobiotic parasite that completes its lifecycle on a single host. These simple aquatic fungi are long-cycled chytrid within the phylum Chitridiomycota. Members of this phylum are holocarpic and do not produce hyphae, but instead has the form of a thallus comprised of sporangia. Two forms of sporangia are known, an asexual so-called summer stage and a sexual so-called winter stage (resting spores). The sporangia contain 200-300 motile zoospores. The summer or “swarm stage” results from host infection by haploid zoospores in which a sorus of one to nine sporangia form, and the winter or “resting stage” results from infection by conjugated (diploid) biflagellated zoospores. Both sporangial types germinate to release pear-shaped motile zoospores with posterior flagella. The resting sporangia are golden brown, ridged, and spheroidal. When conditions are suitable, i.e. soil temperature and water, the rapidly reproducing summer sporangia release their zoospores thus setting up repeated infection cycles of 10-12 days, leading to exponential increase in disease (Weiss, 1925).

At the same time, winter sporangia are formed that can overwinter in the infection zones where there is parenchymatous tissues on of the potato. The resting spores induce hypertrophy of the infected tissue resulting in the so-called warts. During the winter, infected tissue will continually rot in the soil months to release the resting spores into the soil. Resting spores can remain viable for at least 50 years and possibly longer. The chitinous/melaninized wall of the resting spore is extremely chemo-resistant and this resistance and longevity represses any control measures. Conditions favorable for disease development include cool summers with average temperatures of 18°C or less, winters of approximately 160 days at or below 5°C, and annual precipitation of 70 cm or higher. These conditions can be found in parts of the Eastern United States and the Great Lakes but are extremely rare in California.

Hosts: Solanum tuberosum (potato) is the principal host of the pathogen. *Synchytrium endobioticum* has been experimentally transferred to other members of the family Solanaceae, including *Datura* spp. (jimsonweed), *Nicandra physalodes* (apple of Peru), *Nicotiana rustica* (Aztec tobacco), *Nicotiana* spp. (tobacco), *Physalis alkekengi* (=*P. franchetii*) (hozuki), *Schizanthus* spp., *Solanum* spp. (nightshade), *S. americanum* (=*S. nodiflorum*) (American nightshade), *S. chacoense* (bitter wild potato), *S. commersonii* (Commerson's nightshade), *S. dulcamara* (bittersweet nightshade), *S. dulcamara* var. *villosissimum* (climbing nightshade), *S. jamesii* (wild potato), *S. nigrum* (black nightshade), *S. nodiflorum*, *S. pimpinellifolium* (currant tomato), *S. pseudocapsicum* (Jerusalem-cherry), *S. sisymbriifolium* (sticky nightshade), and *S. villosum* (red nightshade). There is one report from 1920 (Lyman et al.) describing *S. lycopersicum* (tomato) becoming infected with *S. endobioticum* when grown in infested soils, but there is no evidence that tomato is more than a reservoir host, and not damaged by infection (CABI, 2021; Farr and Rossman, 2021).

Symptoms: Above ground, infected plants may develop general symptoms of reduced vigor, including yellowing or slow growth. Galls ("warts") occasionally form on the upper stem, leaf, or flowers. They are green to brown, turning black at maturity, and are prone to decay. The disease may not be noticed until tubers are lifted during harvest. The most diagnostic symptom are galls on below-ground portions including the stem base, stolon buds, and tuber eyes. Galls will vary in shape but are mostly spherical, warty outgrowths, ranging from 1 to 8 cm in diameter, but may become larger in some instances. Belowground galls are white to brown and turn black as they decay. The galls act as a sink for nutrients and increase rapidly in size at the expense of the tubers, which may entirely transform into wart like galls (Franc, 2007).

Tubers may be so disfigured that they become almost unrecognizable, especially if they are infected early in development and continually develop galls over a longer period. Tuber galls at harvest may become desiccated and barely noticeable or they may decay. Disease can continue developing during storage. Although potato wart does not kill the plant, the meristematic tissue of new sprouts may be so severely attacked that they fail to emerge from seed tubers. True potato roots are not infected (Franc, 2007).

Transmission: Synchytrium endobioticum has a very limited capacity for natural spread; it is without vectors and relies on the movement of infected soil and water. *S*porangia are dispersed over long distances through the movement and trade of infected seed potato tubers or tubers contaminated with infested soil (Obidiegwu et al., 2014). It can also be spread by moving infested soil with farm machinery, equipment and tools, and boots (Hampson and Coombes, 1996). Manure from animals that have fed on infected tubers may also spread the disease. Earthworms have been found to serve as means of inoculum dispersal, and resting sporangia can be dispersed by wind-blown soil or by flowing surface water (Franc, 2007).

Damage Potential: Synchytrium endobioticum requires cool, wet soils during tuber development to infect the plants. A soil temperature of 8°C and free water is required for the germination of both winter and summer sporangia and for the swimming of zoospores (Hampson, 1993). Cool summers with average temperatures of 18°C or less, winters of approximately 160 days at or below 5°C (over 5

months), and annual precipitation of 70 cm or more are critical for the development of the disease, and generally it will not occur in climates without these characteristics.

As this pathogen is a USDA select agent, any detection would result in complete crop destruction and an extended field quarantine that would prohibit growing potatoes or any other possible host.

Worldwide Distribution: Although pockets of infestation are globally distributed, rigorous regulatory measures have prevented or limited general distribution of the pathogen beyond many of these foci. Africa: *Tunisia, South Africa*. Americas: *Canada, Bolivia, Falkland Islands, Peru.* Asia: *Bhutan, China, India, Nepal*. Europe: *Armenia, Belarus, Bulgaria, Czechia, Denmark, Estonia, Faroe Islands, Finland, Georgia, Germany, Greece, Ireland, Italy, Luxembourg, Montenegro, Netherlands, Poland, Romania, Russia, Slovakia, Sweden, Turkey, Ukraine, United Kingdom*. Oceania: *New Zealand*

Official Control: *Synchytrium endobioticum* is a highly regulated pest on United States Department of Agriculture official list of select agents and toxins (https://www.selectagents.gov/sat/list.htm). As for all agents on the list, any culture collections, plant inoculations, or research is tightly regulated and requires specific Federal permits. Should potato wart be found in the United States, there is a recovery plan included in the National Plant Disease Recovery System (NPDRS) called for in Homeland Security Presidential Directive Number 9. Plant Protection and Quarantine (PPQ) develops the New Pest Response Guidelines in preparation for potential future pest introductions. The new pest response guideline for potato wart is as follows (updated December 2020): https://www.aphis.usda.gov/plant_health/plant_pest_info/potato/downloads/pvy/nprg-synchytrium-endobioticum.pdf

Synchytrium endobioticum is on the EPPO's A1 list for Argentina, Azerbaijan, Bahrain, Brazil, Chile, China, East Africa, Egypt, Kazakhstan, Paraguay, Uruguay, and Uzbekistan. It is on the A2 list for the Asia and Pacific Plant Protection Commission, the Comite de Sanidad Vegetal del Cono Sur, the Eurasian Economic Union, the European and Mediterranean Plant Protection Organization, the European Union, Georgia, the Inter-African Phytosanitary Council, Jordan, the Pacific Plant Protection Organization, Russia, Southern Africa, Turkey, and Ukraine. It is a quarantine pest for Belarus, Canada, Israel, Mexico, Morocco, New Zealand, Norway, Tunisia, and the United States (EPPO, 2021). *Synchytrium endobioticum* is on the USDA PCIT's harmful organism list for the following countries: Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Azerbaijan, Belize, Benin, Bosnia and Herzegovina, Botswana, Brazil, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China, Democratic Republic of the Congo, Costa Rica, Cote d'Ivoire, Ecuador, Egypt, Equatorial Guinea, Ethiopia, the Eurasian Customs Union, the European Union, French Polynesia, Gabon, Gambia, Georgia, Ghana, Guatemala, Guinea, Guinea-Bissau, Holy See (Vatican City State), Honduras, Iceland, Indonesia, Israel, Jamaica, Japan, Jordan, Korea, Republic of, Lesotho, Liberia, Madagascar, Mali, Mauritania, Mauritius, Mexico, Moldova, Republic of Monaco, Morocco, Mozambique, Myanmar, Namibia, Nepal, New Caledonia, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Paraguay, Qatar, Republic of North Macedonia, Rwanda, Saint Lucia, San Marino, Saudi Arabia, Senegal, Serbia, Sierra Leone, Somalia, South Africa, Sri Lanka, Svalbard and Jan Mayen, the

Syrian Arab Republic, Taiwan, Tajikistan, Thailand, The Kingdom of Eswatini, Timor-Leste, Togo, Tunisia, Turkey, Turkmenistan, Ukraine, the United Arab Emirates, United Kingdom, Uruguay, Uzbekistan, Viet Nam, and Zimbabwe (USDA, 2021).

California Distribution: None

California Interceptions: None

The risk *Synchytrium endobioticum* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** The requirements of the pathogen for long cold winters and cool wet summers greatly limit the parts of California where this disease could develop.

   Evaluate if the pest would have suitable hosts and climate to establish in California.

   Score: **1**

   - Low (1) Not likely to establish in California; or likely to establish in very limited areas.

   - Medium (2) may be able to establish in a larger but limited part of California.

   - High (3) likely to establish a widespread distribution in California.

2) **Known Pest Host Range:** The host range is limited to potatoes, and a few other solanaceous plants and weeds that could act as reservoir hosts.

   Evaluate the host range of the pest.

   Score: 2

   - Low (1) has a very limited host range.

   - Medium (2) has a moderate host range.

   - High (3) has a wide host range.

3) **Pest Reproductive Potential:** *Synchytrium endobioticum* is an obligate parasite that can only reproduce on the living tissues of the host plant. When not actively growing, it can survive as resting spores in the soil for at least 50 years. It spreads naturally with the movement of soil and artificially with infected seed potatoes and any human mediated movement of contaminated soil.

   Evaluate the natural and artificial dispersal potential of the pest.

   Score: 2

   - Low (1) does not have high reproductive or dispersal potential.

   - Medium (2) has either high reproductive or dispersal potential.

   - High (3) has both high reproduction and dispersal potential.

4) **Economic Impact:** This pathogen is the highest level of quarantine significance for the USDA. Any detections in the United States would have serious implications for seed potato production, table potato production, and trade between states and other countries. It can be moved with water.

Evaluate the economic impact of the pest to California using the criteria below.

Economic Impact: A, B, C, D, G

A. The pest could lower crop yield.
B. The pest could lower crop value (includes increasing crop production costs).
C. The pest could trigger the loss of markets (includes quarantines).
D. The pest could negatively change normal cultural practices.
E. The pest can vector, or is vectored, by another pestiferous organism.
F. The organism is injurious or poisonous to agriculturally important animals.
G. The organism can interfere with the delivery or supply of water for agricultural uses.

Economic Impact Score: 3

- Low (1) causes 0 or 1 of these impacts.
- Medium (2) causes 2 of these impacts.
- High (3) causes 3 or more of these impacts.

5) **Environmental Impact:** This pathogen has resting spores capable of surviving at depth in soils for at least 50 years. Once in a field, it would be nearly impossible to eradicate and allow potato production to resume. There are reservoir hosts, members of Solanaceae whose roots could support limited reproduction of the pathogen. Any detections even in home gardens could trigger an Emergency Action Notice for eradication from the USDA.

Evaluate the environmental impact of the pest to California using the criteria below

Environmental Impact: A, D, E

A. The pest could have a significant environmental impact such as lowering biodiversity, disrupting natural communities, or changing ecosystem processes.
B. The pest could directly affect threatened or endangered species.
C. The pest could impact threatened or endangered species by disrupting critical habitats.
D. The pest could trigger additional official or private treatment programs.
E. The pest significantly impacts cultural practices, home/urban gardening or ornamental plantings.

Environmental Impact Score: 3

- Low (1) causes none of the above to occur.
- Medium (2) causes one of the above to occur.
- High (3) causes two or more of the above to occur.

Consequences of Introduction to California for *Synchytrium endobioticum:* Medium

Add up the total score and include it here. **11**
-Low = 5-8 points
-**Medium = 9-12 points**
-High = 13-15 points

6) **Post Entry Distribution and Survey Information**: Evaluate the known distribution in California. Only official records identified by a taxonomic expert and supported by voucher specimens deposited in natural history collections should be considered. Pest incursions that have been eradicated, are under eradication, or have been delimited with no further detections should not be included.

Evaluation is 'not established'.

Score: 0
-Not established (0) Pest never detected in California or known only from incursions.
-Low (-1) Pest has a localized distribution in California or is established in one suitable climate/host area (region).
-Medium (-2) Pest is widespread in California but not fully established in the endangered area, or pest established in two contiguous suitable climate/host areas.
-High (-3) Pest has fully established in the endangered area, or pest is reported in more than two contiguous or non-contiguous suitable climate/host areas.

7) **The final score is** the consequences of introduction score minus the post entry distribution and survey information score: (Score)

Final Score: *Score of Consequences of Introduction – Score of Post Entry Distribution and Survey Information* ***= 11***

Uncertainty:

Synchytrium endobioticum has been experimentally transferred to several other members of the family Solanaceae, including tomato and nightshade, but their status as hosts is uncertain. New biotypes of the pathogen are continually evolving and could potentially be adapted to warmer and dryer environments.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Synchytrium endobioticum* is A.

References:

CABI Invasive Species Compendium 2021. *Synchytrium endobioticum*. https://www.cabi.org/cpc/datasheet/52315 . Accessed 8/23/2021

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Hampson, M. C. 1993. History, biology and control of potato wart disease in Canada. Can. J. Plant Pathol. 15:223-244.

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Putnam, M.L. and Hampson, M. C. 1989. Rediscovery of *Synchytrium endobioticum* in Maryland. American Potato Journal, vol. 66: 495-501.

USDA Phytosanitary Certificate Issuance and Tracking System, Phytosanitary Export Database (PExD) Harmful Organisms Database Report. *Synchytrium endobioticum*. Accessed 8/23/2021

Weiss, F. 1925. The conditions of infection in potato wart. American Journal of Botany 12(7):413-443

Responsible Party:

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***Comment Period: 09/24/2021 through 11/08/2021**

***NOTE:**

You must be registered and logged in to post a comment. If you have registered and have not received the registration confirmation, please contact us at permits[@]cdfa.ca.gov.

Comment Format:

- Comments should refer to the appropriate California Pest Rating Proposal Form subsection(s) being commented on, as shown below.

  Example Comment:

  Consequences of Introduction: 1. Climate/Host Interaction: [Your comment that relates to "Climate/Host Interaction" here.]

- Posted comments will not be able to be viewed immediately.
- Comments may not be posted if they:

  Contain inappropriate language which is not germane to the pest rating proposal;

  Contains defamatory, false, inaccurate, abusive, obscene, pornographic, sexually oriented, threatening, racially offensive, discriminatory or illegal material;

  Violates agency regulations prohibiting sexual harassment or other forms of discrimination;

  Violates agency regulations prohibiting workplace violence, including threats.

- Comments may be edited prior to posting to ensure they are entirely germane.
- Posted comments shall be those which have been approved in content and posted to the website to be viewed, not just submitted.

Proposed Pest Rating: A
