California Pest Rating Proposal for

Clavibacter sepedonicus (Spieckermann and Kotthoff 1914; Davis et al. 1984) Li et al. 2018

Potato ring rot

Current Pest Rating: none

Proposed Pest Rating: A

Domain: Bacteria, Phylum: Actinobacteria,
Class: Actinobacteria, Subclass: Actinobacteridae,
Order: Actinomycetales, Suborder: Micrococcineae,
Family: Microbacteriaceae

Comment Period: 11/16/2023 through 12/31/2023

Initiating Event:

This pathogen has not been through the pest rating system. The risk to California from *Clavibacter sepedonicus* is described herein and a permanent rating is proposed.

History & Status:

Background: Bacterial ring rot of potato (*Solanum tuberosum*) is a serious disease caused by the gram-positive coryneform bacterium *Clavibacter sepedonicus*. It is an important quarantine disease that threatens the potato industry worldwide. Since its original description and report in 1906 in Germany by Appel, the management of ring rot has been a major problem with the bacterium being transmitted long distances via infected tubers for planting. The first name was *Bacterium sepedonicum* Spieckermann and Kotthoff. Dowson (1942) transferred the species into the genus *Corynebacterium* ('club' bacterium) (Lehmann and Neumann, 1896) and named it *Corynebacterium sepedonicum*. The pathogen was transferred to the genus *Clavibacter* and named *Clavibacter michiganensis* subsp. *sepedonicum* as one of the five subspecies within the species (Davis et al., 1986). To follow the rules of nomenclature for bacterial taxonomy, the name was later changed to *C. michiganensis* subsp. *sepedonicus*. A reclassification of *Clavibacter* spp. into six new species was proposed based on the genomic information by Li et al., 2018. The original subspecies of *C. michiganensis* sensu lato were elevated to species level and the potato ring rot pathogen was designated *Clavibacter sepedonicus*. It is a monophyletic taxon comprising only the strains originating from potato (Osdaghi et al., 2020).

The disease symptoms include interveinal chlorosis on leaflets leading to necrotic areas and systemic wilt on growing potato plants. On infected tubers, vascular tissues become yellowish-brown with a cheesy texture due to bacterial colonization and decay. To prevent the spread of the disease, it is important to maintain strict testing and quarantine requirements.

Potato is the only economic host of *C. sepedonicus*. The Potato Association of America recommends that state governments in the U.S. coordinate uniform processes to manage seed certification. Due to the zero-tolerance approach for this disease, the detection of the pathogen in seed potatoes results in the loss of certification for all seed lots on a farm, triggering requirements for disinfecting stores and equipment, and other domestic regulatory steps. The rejection of seed potatoes in international trade is another immediate consequence of any detection.

Potatoes are grown on approximately 28,000 acres in California and had an estimated total value of $232M in 2021 (https://www.cdfa.ca.gov/Statistics/PDFs/2022_Ag_Stats_Review.pdf). Because of the diversity of climates, California is the only state that produces spring, summer, fall, and winter-marketed potatoes. California has four major potato-producing regions: the Klamath/Tulelake basin in Siskiyou and Modoc counties, San Joaquin County, Kern County, and Los Angeles County. California is the nation's largest producer of spring potatoes, and the majority are grown in Kern County (Lazicki et al., 2016).

Hosts: Clavibacter sepedonicus is only known to cause disease in potatoes (Solanum tuberosum). Sugar beet (*Beta vulgaris* var. *saccharifera*) has been described as a natural symptomless host, with the pathogen isolated from sugar beet seeds and roots (Bugbee and Gudmestad, 1988). Natural infection of tomato (*Solanum lycopersicum*) with *C. sepedonicus* has also been reported (van Vaerenbergh et al., 2016). In inoculation tests in the lab, many members of the Solanaceae, including tomatoes and eggplant (*Solanum melongena*), are susceptible.

Symptoms: Symptoms of ring rot disease can be seen in potatoes during the growing season, with cool and humid weather most favorable for severe disease development (Kawchuk, et al., 1998). Early symptoms include the interveinal spaces of the leaves becoming light green to pale yellow. Leaves may wilt and become slightly rolled at the margins (Romanenko et al., 2002). As the disease progresses, leaves can become necrotic, starting from the margins (De Boer and Slack, 1984). Plants are often reduced in size and appear stunted, with dieback of infected leaflets, leaves, or stems. When disease levels are low, there may be no symptoms in the field; when they are severe, there may be complete necrosis of the leaves, and entire plant collapse (Kawchuk, et al., 1998).

Ring rot symptoms in infected tubers are usually not seen until after harvest or during storage. Symptoms start as slight glassiness or translucence of the tissue without softening around the vascular system. Over time, ring rot symptoms may include vascular tissue becoming discolored (creamy yellow) and cheesy soft in texture; milky droplets of bacterial slime are exuded when tubers are cut and squeezed. Brown discoloration of the stems and vascular ring in the tubers may be seen. Sometimes exudate can sometimes be squeezed from wilted stems (Howard et al., 1994). There can be a complete

breakdown of the vascular rings extending throughout the tuber (Kawchuk et al., 1998). The exterior of infected tubers can show surface cracks and dark blotches, and the entire tuber can rot. Ring rot is usually odorless; bacterial soft rots of tubers have a very strong smell of decay.

Symptoms of ring rot can easily be mistaken for other potato diseases such as brown rot of potato (*Ralstonia solanacearum*), late blight (*Phytophthora infestans*), wilt (*Verticillium albo-atrum*), and stem canker (*Thanatephorus cucumeris*). Symptoms can be variable or even resemble senescence, drought, or mechanical damage. Visual field inspection is not sufficient to detect disease in the plants and some secondary infections can mask typical ring rot symptoms in the tubers (Osdaghi et al., 2022).

Transmission: Potato tubers for planting carrying the ring rot pathogen can be symptomless and latently infected, and they are the main source of primary inoculum in areas with no history of the disease (Franc, 1999; Nelson, 1982). The bacterium can persist in a field on the surface of or inside unharvested potato tubers. Daughter tubers of volunteer potato plants growing within a non-potato crop cultivated in rotation with potatoes could also act as reservoirs of the pathogen in the field. Once an infected potato tuber is planted, the pathogen multiplies rapidly and passes through the vascular system into the stems and petioles, from where it reaches the roots and maturing daughter tubers. Earliest infections can be observed when the tuber is cut across the heel end as narrow glassy to cream-yellow zones along the vascular tissue near the stolon end. The pathogen is adapted to an endophytic lifestyle, proliferating within plant tissues and unable to persist in the absence of plant material lasting only weeks at temperatures above 15 °C. It also has a low survival rate in surface water. Wounds are necessary for the entry of the ring-rot bacteria into tubers. Potato seed-cutting operations enhance the spread of the pathogen. It can survive on packaging materials such as potato bags, barn walls, crates, and machinery, and it can be transferred to healthy tubers (van der Wolf et al., 2005). High temperatures stimulate disease development while lower temperatures are more favorable for the survival of the pathogen (Westra and Slack, 1994).

Damage Potential: Clavibacter sepedonicus causes early death of plants, rotting of tubers, and extensive yield reduction. A high level of infection can cause total crop loss. However, with current certification practices for seed potatoes, the disease occurs only sporadically and generally at low levels, even in regions where the disease is endemic (CABI, 2023). In North America, *C. sepedonicus* is a regulated pest of seed potatoes. Even with low incidence in the field, up to 80% of seed tubers can become infected when they are chopped and mechanically planted (EFSA et al., 2019). Direct losses from wilting and tuber rotting are typically minimal, particularly in environments with contemporary seed verification processes. Any detections, even of latent infections, can result in significant expenses from lost export markets and the need to reject contaminated seed batches as a preventative step. These actions include losing certification, preventing additional planting, buying new seed stocks, paying for disinfection, disposing of contaminated and related crops, and dealing with the fallout on export trade and reputation (Charkowski et al., 2020).

Worldwide Distribution: Asia: China, Japan, Kazakhstan, Nepal, North Korea, Pakistan, South Korea, Uzbekistan, the Asian part of Russia; Europe: Belarus, Bulgaria, Czech Republic, Estonia, Finland, Georgia, Germany, Greece, Hungary, Latvia, Lithuania, Norway, Poland, Romania, European part of

Russia, Slovakia, Spain, Sweden, Turkey, Ukraine; and North America: Canada, Mexico, United States of America (Colorado, Idaho, Kansas, Maine, New York, North Dakota, Oregon, Washington, Wisconsin) (CABI, 2023; Osdaghi et al., 2022).

Official Control: *Clavibacter sepedonicus* is on the EPPO's A1 list for Argentina, Azerbaijan, Brazil, Comunidad Andina, Chile, Comite de Sanidad Vegetal del Cono Sur, Egypt, Georgia, Inter-African Phytosanitary Council, Jordan, Paraguay, Switzerland, United Kingdom, and Uruguay; A2 list for Asia and Pacific Plant Protection Commission, Bahrain, European Plant Protection Agency, and Türkiye; A2 Quarantine pest (Annex II B): European Union; Quarantine pest: Canada, China, Israel, Mexico, Moldova, Morocco, New Zealand, Norway, Tunisia, and the United States; Regulated non-quarantine pest: Russia, and Ukraine (EPPO, 2023).

Clavibacter sepedonicus is on the USDA PCIT's Harmful organisms list for Albania, Argentina, Azerbaijan, Belize, Brazil, Canada, Chile, China, Colombia, Dominican Republic, Ecuador, Egypt, European Union, Guatemala, Holy See (Vatican City State), Honduras, India, Israel, Jordan, Madagascar, Mauritius, Mexico, Monaco, Morocco, Mozambique, Namibia, New Caledonia, New Zealand, Nicaragua, Norway, Panama, Paraguay, Peru, Qatar, Republic of Moldova, Republic of North Macedonia, San Marino, Serbia, South Africa, Svalbard and Jan Mayen, Taiwan, Thailand, Tunisia, United Kingdom, Uruguay, and Zambia (USDA PCIT, 2023).

Clavibacter sepedonicus is a regulated (non-quarantine) plant pathogen in seed potato production in North America. In the U.S., seed certification is regulated at the state level with standard protocols. Detection of the pathogen in seed potatoes results in loss of certification of all seed lots on a farm, and requirements for disinfection of equipment and stores along with other domestic regulatory actions, with a zero - tolerance policy for this disease in trade. With effective certification programs, the disease occurs only sporadically and generally at low levels in regions where it is endemic (Osdagni et al., 2022).

California Distribution: none

California Interceptions: none

The risk that *Clavibacter sepedonicus* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** This pathogen is likely to occur wherever potatoes are grown.

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

Score: **3**

- Low (1) Not likely to establish in California; or likely to establish in very limited areas.
- Medium (2) may be able to be established in a larger but limited part of California.

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

2) **Known Pest Host Range:** This disease is limited to potatoes.

Evaluate the host range of the pest.

Score: 1

- 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:** Under favorable conditions, *Clavibacter* can increase exponentially. Dispersal through infected seed potatoes is a major pathway for dissemination.

Evaluate the natural and artificial dispersal potential of the pest.

Score: 3

- 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 disease reduces yield and value of potato crops, especially seed crops. It is a regulated pathogen here and in many other countries.

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

Economic Impact: A, B, C

A. The pest could lower crop yield.
B. The pest could lower crop value (including increasing crop production costs).
C. The pest could trigger the loss of markets (including 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:** Detection of this pathogen triggers significant regulatory protocols aimed at eradication.

Evaluate the environmental impact of the pest on California using the criteria below.

Environmental Impact: D

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: 2

- 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 *Clavibacter sepedonicus:* Medium

Add up the total score and include it here. **12**
-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 the 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* ***= 12***

Uncertainty: none

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for ***Clavibacter sepedonicus*** **is A.**

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Responsible Party:

Heather J. Scheck, Primary Plant Pathologist/Nematologist, CDFA/PHPPS ECOPERS, 1220 N St Rm 221, Sacramento, CA 95814 Phone: (916) 654-1017, permits[@]cdfa.ca.gov.

***Comment Period: 11/16/2023 through 12/31/2023**

***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
