California Pest Rating Proposal for

Phytophthora rubi (W.F. Wilcox & J.M. Duncan) Man in 't Veld 2007
≡ *Phytophthora fragariae* var. *rubi* W.F. Wilcox & J.M. Duncan 1993

Raspberry root rot

Current Pest Rating: None

Proposed Pest Rating: B

Domain: Eukaryota, Kingdom: Chromista,
Phylum: Oomycota, Class: Oomycetes,
Order: Peronosporales, Family: Peronosporaceae

Comment Period: 01/04/2022 through 02/18/2022

Initiating Event:

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

History & Status:

Background: Raspberries and blackberries (*Rubus* spp.) are important crops for California with a recent valuation of $386M (CDFA: California Agricultural Statistics Review, 2019-2020) and an 18th place ranking in export value at $162M. California leads the U.S. in the production of fresh red raspberries, while Washington leads in the production of red raspberries for processing. Most raspberries from California are produced in four counties: Ventura, Santa Cruz, Santa Barbara, and Monterey. Raspberries are commonly grown under protected structures, usually plastic covered, high-hoop tunnels, which extend the production season and protect the fruit from direct sun and rain/fog damage.

Raspberries are typically produced from bare root transplants. They can be managed as a perennial crop that produces for a decade or more, but to maintain acceptable quality and yield Central Coast growers typically manage raspberries so that they produce between two and five crops prior to removal and replanting. Coastal raspberry growers switched in the 1980s from floricane spring-bearing varieties to proprietary primocane fall-bearing varieties to achieve two harvests a year. Primocane-bearing varieties allow growers to successfully produce a high-quality crop in low- or no-chill coastal

locations and further manipulate time to harvest and yield with pruning and other management practices (Torte et al., 2016).

Phytophthora root rot can be caused by multiple species and is a serious pathogen of raspberries worldwide. *Phytophthora rubi* is common in Washington where it has caused up to 100% plant mortality in heavy or saturated soils in areas with cool temperatures (Gigot et al., 2013). Root rot symptoms begin early in the season and become most severe when the fruit begins to ripen. Until 2007, *P. rubi* was considered a variety of *P. fragariae* because these two species (both in Clade 7a) are very similar in morphology and were differentiated only by host preference. *Phytophthora fragariae* is a pathogen of strawberries. Man in't Veld (2007) used allozyme profiles and the mitochondrial cytochrome oxidase I gene to show that *P. rubi* should be promoted from a subspecies of *P. fragariae* to a distinct species on its own. Tabima et al. (2018), used genotype-by-sequencing to characterize the genetic diversity in domestic and foreign populations of *P. rubi*. They confirmed that *P. rubi* is a monophyletic species separate from *P. fragariae*, with low genetic diversity across the western United States. They also provided evidence of its migration from California and Oregon into Washington and from California into Europe.

Hosts: Rubus fructicosus (blackberry) and *Rubus idaeus* (raspberry) (CABI CPC; 2021)

Symptoms: Symptoms include a general lack of vigor and a sparse plant stand. As parasitism from the pathogen rots the roots below ground, there is wilting and death of canes above ground, from early spring to late summer. Wilting becomes more noticeable during warmer, drier conditions. Leaves turn yellow or bronze and develop scorch symptoms before dying. Dead leaves usually remain attached to their canes. Just as the fruit begins to ripen, the floricanes will start to die causing the fruit to be undersized. Primocanes usually begin to wilt from the tip down. The cane tips bend over, exposing the silvery undersurfaces of the leaves and forming a shepherd's crook. New canes may be damaged or killed before they break the soil surface. Often only one or a few canes of a plant will die while the rest of the plant appears healthy. Multiple plants in low lying areas of the field can die, leaving large open patches known as disease pockets (Pscheidt and Ocamb, 2020; Weiland et al., 2018).

Lesions initially formed on the roots may extend up into the canes. Scraping the epidermis will show a sharp transition zone between the healthy white or bright-green root and stem tissues and the reddish-brown diseased, rotted tissues. Analysis of root systems on symptomatic plants reveals that larger-diameter roots will be killed with few, if any, smaller-diameter feeder roots left behind to support the vines. New roots may form above the decayed root system during the summer and the plants may appear to recover, but *Phytophthora* growth and resumption of root killing will start again during the wet months of fall and winter (Pscheidt and Ocamb, 2020; Weiland et al., 2018).

Transmission: The life cycle of *P. rubi* is very similar to that of *P. fragariae*. It survives in soil as resistant oospores. Inoculum, primarily as sporangia and zoospores, rapidly builds up and spreads. Repeating cycles of infection and sporulation can occur. Chlamydospores are not known to be formed. Anything that moves infested soil including equipment, tools, containers, workers, and irrigation water, even streams, can potentially move inoculum of *P. rubi*. As raspberries and blackberries are vegetatively propagated, it is likely that long distance movement has been with contaminated nursery stock.

Damage Potential: Phytophthora root rot caused by *P. rubi* is the most serious pathogen of red raspberry worldwide (Wilcox and Cooke 2017). *Phytophthora rubi* was long considered a cool weather pathogen, assumed to be most active and infective during cool, wet winters, such as occur in Western Oregon, Washington, and British Columbia, with maximum symptom expression in late summer (Weiland et al., 2018). Recent work by Graham et al. (2021) shows that *P. rubi* is more likely to infect during the spring and summer months when soil temperatures are much warmer, in the range of 15-20^{o}C. The soil moisture parameters they tested did not affect the pathogenicity scores.

Other pathogens with symptoms that can be confused with *P. rubi* or can co-occur with *P. rubi,* include other *Phytophthora species, Verticillium dahliae* and *Pratylenchus penetrans.* Many commercial raspberry fields suffer from a combination of these as soilborne disease complexes that severely reduce crop productivity and the longevity of field plantings (Weiland et al., 2018).

Worldwide Distribution: Europe: *Austria, Belgium, Croatia, Czechia, France, Germany, Ireland, Netherlands, Norway, Slovenia, Sweden, Switzerland, Ukraine, United Kingdom* (England, Northern Ireland, Scotland); North America: *Canada, United States* (California, New York, Ohio, Oregon, Washington); Oceania: *Australia*; South America: *Chile* (CABI-CPC, 2021; Farr and Rossman, 2021).

Official Control: *Phytophthora rubi* is on the USDA PCIT's harmful organism list for Mexico, Norway, and Peru (USDA, 2021). It is on the EPPO's A2 list for Jordan and the European Plant Protection Organization, and a quarantine pest for Mexico, Morocco, Norway, and Tunisia (EPPO, 2021).

California Distribution: There are multiple official records of *Phytophthora* spp. on *Rubus* spp. in California where the identification was made by immunoassay, which does not identify *Phytophthora* to species. Some of these detections could have been *P. rubi* or could have been other species known to be pathogenic on *Rubus* spp. including *P. cactorum*, *P. citricola*, or *P. bishii*. Multiple experts have reported isolates of *P. rubi* collected from raspberry in California (Tabima et al., 2018; Stewart et al., 2014; Graham et al., 2021).

California Interceptions: none

The risk *Phytophthora rubi* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** It is likely that *P. rubi* would be able to establish wherever its hosts are grown.

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

   Score: **2**

   - 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 restricted to raspberries and blackberries.

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:** *Phytophthora* spp. have a high reproductive potential with multiple spore types that can spread in soil and with water.

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:**100% raspberry plant mortality from *P. rubi* has been reported in heavy or saturated field soils (Gigot et al. 2013). There are frequent requests for phytosanitary certificates for raspberry plants and *P. rubi* is a quarantine pest in several countries. Phytophthoras are frequently moved with irrigation water and streams. Root rot diseases significantly reduce the productivity and longevity of the plants. Economic damage to blackberries has not been reported (Koike et al., 2009).

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

Economic Impact: A, 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:** American red raspberry is not native to California. There are several native and introduced *Rubus* species that occur widely in coastal counties, proximal to commercial raspberry and

blackberry plantings. Wild raspberry species *Rubus glaucifolius, R. lasiococcus, and R. leucodermis,* are relatively widespread in the state. Their susceptibility to *P. rubi* is unknown. Phytophthoras are difficult to control and nearly impossible to eradicate from soils.

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 *Phytophthora rubi:* 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.

Researchers have published reports of this pathogen from California, mostly from the Monterey Bay area.

Evaluation is 'low'.

Score: -1
-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:

Although there are no known hosts other than *Rubus* spp., *Phytophthora rubi* may be able to survive on other rosaceous hosts

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Phytophthora rubi* is B.

References:

CABI Crop Production Compendium 2021. *Phytophthora rubi* https://www.cabi.org/cpc/datasheet/40993 Accessed 12/6/21

EPPO Global Database. 2021. *Phytophthora rubi* https://gd.eppo.int/taxon/PHYTFU. Accessed 12/6/21

Farr, D.F., and Rossman, A.Y. Fungal Databases, U.S. National Fungus Collections, ARS, USDA. Retrieved December 6, 2021, from https://nt.ars-grin.gov/fungaldatabases/

Gigot, J., Walters, T.W. and Zasada, I.A., 2013. Impact and Occurrence of *Phytophthora rubi* and *Pratylenchus penetrans* in Commercial Red Raspberry (*Rubus ideaus*) Fields in Northwestern Washington. International Journal of Fruit Science, 13(4), pp.357-372.

Graham, K.A., Beck, B.R., Zasada, I.A., Scagel, C.F. and Weiland, J.E., 2021. Growth, Sporulation, and Pathogenicity of the Raspberry Pathogen Phytophthora rubi Under Different Temperature and Moisture Regimes. Plant Disease, pp.PDIS-09.

Koike, S. T., Bolda, M. P., Gubler, W. D. and Bettiga, L. J. 2009. UC IPM Pest Management Guidelines: Caneberries UC ANR Publication 3437. Phytophthora root rot. Accessed 12/8/21

Man in 't Veld, W.A. 2007. Gene flow analysis demonstrates that *Phytophthora fragariae* var. *rubi* constitutes a distinct species, *Phytophthora rubi* comb. var. Mycologia 99: 222-226.

Pscheidt, J. W., and Ocamb, C. M., senior editors. 2020. Pacific Northwest Plant Disease Management Handbook [online]. Corvallis, OR: Oregon State University. http://pnwhandbooks.org/plantdisease. Accessed 12/8/2021

Stewart, J.E., Kroese, D., Tabima, J., Larsen, M.M., Fieland, V.J., Press, C.M., Zasada, I.A., and Grunwald, N.J. 2014. Pathogenicity, fungicide resistance, and genetic variability of *Phytophthora rubi* isolates from raspberry (*Rubus idaeus*) in the Western United States. Pl. Dis. 98(12): 1702-1708.

Tabima, J.F., Coffey, M.D., Zazada, I.A. and Grünwald, N.J., 2018. Populations of *Phytophthora rubi* show little differentiation and high rates of migration among states in the western United States. Molecular plant-microbe interactions, 31(6), pp.614-622.

Tourte, L., Bolda, M., and Klonsky, K. 2016. "The Evolving Fresh Market Berry Industry in Santa Cruz and Monterey Counties." California Agriculture 70(3):107-115. Retrieved from: https://doi.org/10.3733/ca.2016a0001

USDA Phytosanitary Certificate Issuance and Tracking System, Phytosanitary Export Database (PExD) Harmful Organisms Database Report. *Phytophthora rubi*. Accessed 12/6/2021

Weiland, J.E., Benedict, C., Zasada, I.A., Scagel, C.R., Beck, B.R., Davis, A., Graham, K., Peetz, A., Martin, R.R., Dung, J.K. and Gaige, A.R., 2018. Late-summer disease symptoms in Western Washington red raspberry fields associated with co-occurrence of *Phytophthora rubi*, *Verticillium dahliae*, and *Pratylenchus penetrans*, but not Raspberry bushy dwarf virus. Plant disease, 102(5), pp.938-947.

Wilcox, W. F., and Cooke, D. E. L. 2017. Phytophthora root rot. Pages 52-56 in: Compendium of Raspberry and Blackberry Diseases and Pests, 2nd ed. R. R. Martin, M. A. Ellis, B. Williamson, and R. N. Williams, eds. American Phytopathological Society, St. Paul, MN.

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: 01/04/2022 through 02/18/2022

*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: B
