EPPO Datasheet: *Phytophthora rubi*

Last updated: 2022-06-03

IDENTITY

Preferred name: *Phytophthora rubi*
Authority: Man in t Veld
Taxonomic position: Chromista: Oomycota: Oomycetes: Peronosporales: Peronosporaceae
Other scientific names: *Phytophthora fragariae var. rubi* Wilcox & Duncan
Common names: root rot of raspberry
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EPPO Categorization: A2 list
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EPPO Code: PHYTFU



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Notes on taxonomy and nomenclature

Phytophthora rubi was originally considered a variety of *P. fragariae*, which was differentiated only by host preference (Wilcox *et al.*, 1993). However, based on analyses of isozyme profiles and cox1 sequences, that demonstrated the absence of gene flow between both taxa, *P. rubi* was described as a distinct species (Man in 't Veld, 2007). Previously, molecular analysis based on RFLP and AFLP patterns of both varieties of *P. fragariae* also indicated that they represented two different genetic entities (Stammler *et al.*, 1993; Brasier *et al.*, 1999). More recently, Adam *et al.* (2020) studied the genome of *P. fragariae* and *P. rubi* isolates and identified a different structure between the two species. Although morphologically and physiologically very similar, isolates of *P. rubi* differ from *P. fragariae* being highly pathogenic to raspberry (*Rubus idaeus*), but cause only small amounts of necrosis in strawberry roots (Wilcox *et al.*, 1993). *Phytophthora rubi* and *P. fragariae* have identical ITS sequences, but differ across other gene regions such as Btub, HSP90, cox1 and NADH1 and, therefore, they can unambiguously separate using multigene phylogenetic analyses (Jung *et al.*, 2017). Recent genotyping-by-sequencing (GBS) analyses showed low genetic diversity across the Western United States populations of *P. rubi*. Demographic analyses suggest that populations of *P. rubi* from the Western United States are the source of pathogen migration to Europe (Tabima *et al.*, 2018).

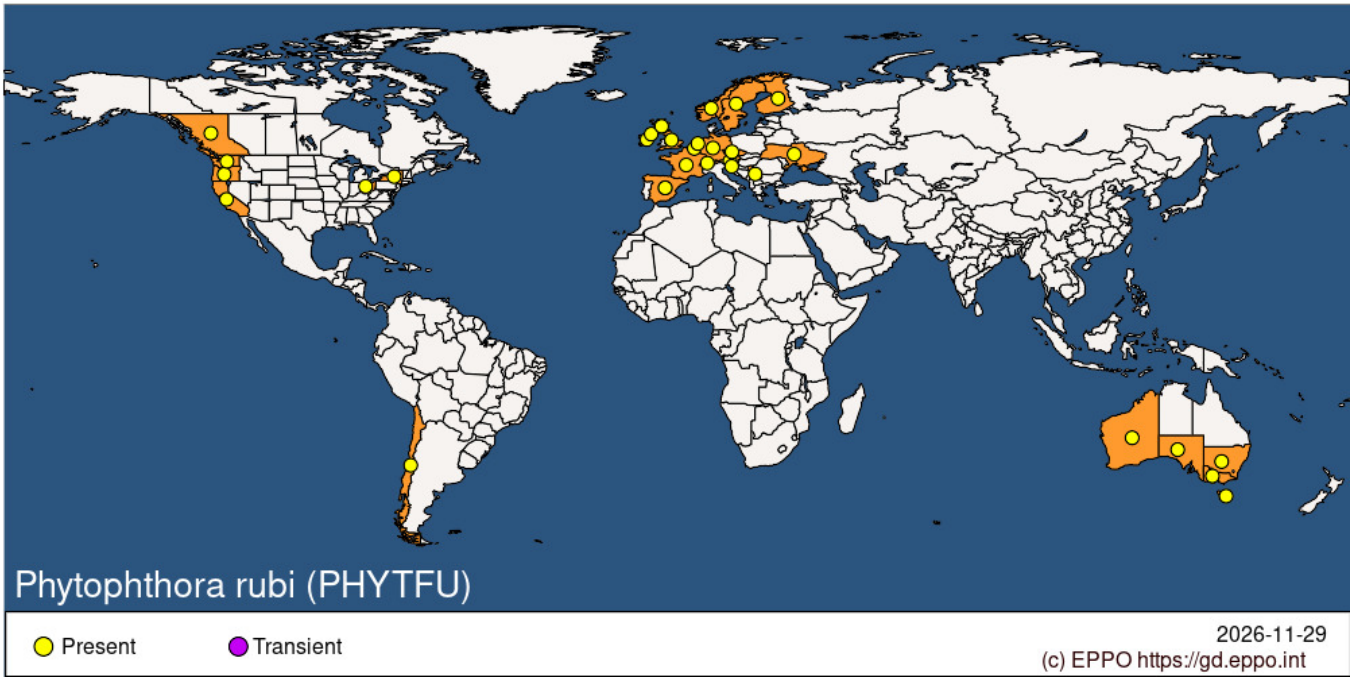
HOSTS

Cultivated raspberries are the principal host, but hybrid berries such as loganberries (*Rubus* × *loganobaccus*) and tayberries (*Rubus fruticosus* × *R. idaeus*) have been found to be naturally infected. However, for tayberries the disease could not be reproduced in inoculation experiments. Some other genera within the tribe Potentilleae, in the family Rosaceae, may be susceptible but have not been tested. Strawberries are not susceptible to *P. rubi*, which does not cause typical red core symptoms. The potential host range in the EPPO region would be mainly raspberries, including *R. idaeus*, *R. occidentalis* and *R. idaeus* hybrids (Wilcox 1989).

Host list: *Rubus fructicosus x Rubus idaeus*, *Rubus hybrids*, *Rubus idaeus*, *Rubus occidentalis*, *Rubus x loganobaccus* , *Rubus x neglectus*

GEOGRAPHICAL DISTRIBUTION

Phytophthora rubi has a cosmopolitan distribution, although less widespread than *P. fragariae*. It was first recorded in England and Scotland in the 1930s (Waterson 1937). Since then, the pathogen has spread mainly in western parts of North and South America, and Canada, Central and Northern Europe, and South-Eastern Australia (Converse & Schwartze, 1968; Boesewinkel, 1982; Duncan *et al.*, 1987; Washington, 1988).



EPPO Region: Austria, Belgium, Czechia, Finland, France (mainland), Germany, Ireland, Netherlands, Norway, Serbia, Slovenia, Spain (mainland, Mainland Spain), Sweden, Switzerland, Ukraine, United Kingdom (England, Northern Ireland, Scotland)
North America: Canada (British Columbia), United States of America (California, New York, Ohio, Oregon, Washington)
South America: Chile
Oceania: Australia (New South Wales, South Australia, Tasmania, Victoria, Western Australia)

BIOLOGY

Phytophthora rubi has similar morphology and growth–temperature relationships to *P. fragariae*. The optimum temperature for growth is 25°C and the maximum temperature lies between 25 - 30°C. Its growth, at the optimum temperature (2.9 mm/d) and 20°C (2.7 mm/d), is faster than *P. fragariae* (Jung *et al*., 2017). Being a homothallic species, it can survive for many years in soil as resistant oospores. When environmental conditions become suitable (wet soil from precipitation or irrigation), pathogen oospores germinate by forming sporangia, which can infect host tissues by direct germination or by release of motile biflagellate zoospores into the soil water. Zoospores are chemotactically attracted by the root tips of the host plant where they penetrate and colonize the root tissues (Duncan and Kennedy, 1989). The pathogen can produce multiple secondary sporangia on infected roots and release zoospores into the soil, and the cycle starts again. Although there are no known natural hosts other than *Rubus* spp. *P. rubi* may be able to survive on other rosaceous hosts. Just as with *P. fragariae*, the rapid build-up and spread of inoculum, the polycyclic nature of the disease, and the production and subsequent survival of oospores are the main factors which make this disease difficult to control and eradicate (Wilcox *et al*., 1993). Unlike, *P. fragariae* there are not yet any reports of races.

DETECTION AND IDENTIFICATION

Symptoms

As with *P. fragariae*, *P. rubi* outbreaks often start from small foci, increasing in size, especially down slopes. Symptomatology includes the development of chlorotic, reddish, scorched, or wilted leaves, thin canopies, stunting, reduced cane production, shriveled fruit and reddish-brown root lesions that may extend up into the canes (Stewart *et al*., 2014). Below ground symptoms may incude discolored, water-soaked necrotic lesions on the roots and crowns, which later results in wilting and dieback of the above-ground canes. Symptoms usually appear on the upper parts of

plants that come under stress in late spring or early summer. Some fruiting canes, i.e. canes in their second year, do not break bud; others break bud but their fruiting laterals wilt and dry out before or at fruiting. When the periderm round the bases of these canes is removed the wood underneath is usually discoloured reddish-brown or brownish-black. There is a dearth of young, first-year canes (primocanes); a very early and useful symptom is the absence in spring of a flush of primocanes in the alleyways between the rows of plants. Young canes wilt to give the appearance of a shepherd's crook. Their foliage becomes bronzed or reddish, long before autumn (premature autumn colouring). Blackish-purple lesions can be also found at the base of many young canes, best seen by removing the periderm, and these can extend for 20-30 cm above soil level. The root systems of affected plants are badly rotten with few white feeder roots, and the thicker roots have internal discoloration often sharply demarcated from white unaffected regions of the root. Root rot symptoms begin early in the growing season and are the most severe in June as fruit begins to ripen. Plant death occurs when enough of the larger roots and canes are girdled. In severe cases, the entire production field may be killed. Several other *Phytophthora* species have been isolated from raspberries affected by root rot, although plants infected by these other species are rarely as severely affected as those attacked by *P. rubi* and lack some of its characteristic symptoms, e.g. the blackish-purple lesions on young canes and large oospores restricted to the stele.

Morphology

The pathogen produces oospores in the infected plant tissues, which are easiest to find in young, soft, rotten roots collected from as high up on the base of the cane as possible. Oospores are limited to the stelar region of rotten roots and are very similar to the oospores of *P. fragariae*, with mature oogonia usually golden-brown, 28-46 µm (mean 39 µm) in diameter with a single aplerotic oospore, 22-44 µm (mean 33 µm) in diameter (Jung *et al.*, 2017). Antheridia are either paragynous or amphigynous. Sporangia are ovoid, ellipsoid, obpyriform, limoniform in shape, ranging 35.6–61.9 µm (mean 50.2 µm) in length and 18.1–37.3 µm (mean 29.3 µm) wide (Jung *et al.*, 2017). Hyphal swellings are elongated, irregular and catenulate. Chlamydospores are not produced.

Detection and inspection methods

The pathogen can be isolated from infected plants tissues, including discolored bases of stems, thick root pieces and fine rootlets using a selective medium for *Phytophthora* (Montgomerie & Kennedy 1983; Brunner-Keinath & Seemüller 1992). It can be also detected from rhizosphere soil samples collected around symptomatic plants using baiting tests (Erwin & Ribeiro 1995).

Pieces of root, some with young buds attached, are collected in late autumn. They are mixed with a soilless compost and the mixture is used to fill flat planting trays. The trays are kept under good lighting and high temperatures and with just enough water to permit the development of the young buds into vigorous shoots. After about 5 weeks the trays are transferred to cool conditions with moderate lighting and copious watering (care should be taken to ensure that the pots drain freely and do not become stagnant). The new conditions encourage the development of the disease if present, typically wilting and yellowing of leaves, stem lesions and root rot with characteristic oospores in the stele.

Early diagnosis can be made by the detection of small amounts of antigen using an ELISA test. PCR-based detection tests can also rapidly detect the pathogen, particularly if integrated with the baiting method. PCR tests have been developed targeting the internal transcribed spacer region of the ribosomal gene repeat (rDNA) using specific primers in nested PCR (Cooke *et al.*, 1990). Although this method was mainly developed for *P. fragariae*, it can also be used for *P. rubi* (Bonants *et al.*, 2004). Rapid, specific and high-throughput sequencing methods may be another opportunity for molecular detection of the pathogen from asymptomatic plants at the control points at import (Liao *et al.*, 2019).

PATHWAYS FOR MOVEMENT

The movement of infected raspberry planting material as well as infested soil are key means of pathogen dispersal within countries and between fields and regions. For example, Graaberg (1994) suggests that this is how *P. rubi* was introduced into Sweden. As is the case for *P. fragariae*, *P. rubi* can spread in surface water run off or drainage flows, and this can be important for local spread as well as spread from infected tissues to healthy plant tissues by rain-splash. Caution must be exercised when irrigating crops as the pathogen has been spread by irrigating with water which had drained from diseased fields, especially in very wet, mild winters. It can also be moved in soil on

implements and machinery.

PEST SIGNIFICANCE

Economic impact

Phytophthora rubi is the most serious pathogen of raspberry worldwide, and it can result in complete crop losses, as large areas are completely killed (Wilcox and Cooke 2017). To establish raspberry plantations requires considerable capital investment, which is recovered over the life of the plantation, usually 10-15 years. This investment is lost if severe outbreaks occur within 2-3 years of planting. The disease is of great importance in France, Germany, Norway, Switzerland and the United Kingdom. In 2013, *P. rubi* was found in 90% of the surveyed raspberry fields in Washington state, with the potential of causing millions of dollars in losses to the industry annually (Gigot *et al*., 2013; Stewart *et al*., 2014).

Control

Phytophthora rubi is difficult to control, as it overwinters in the soil as oospores that can initiate epidemics in subsequent years. An integrative management approach, including development of resistant raspberry cultivars, fungicides and fumigants, and avoidance of wet soils, is suggested for control of this disease (Wilcox *et al.*, 1999). A number of fungicides such as Mefenoxan (Ridomil) and phoshorous acid (Aliette, Agri-Fos and Rampart) have proved to be effective to control raspberry root rot in USA, although some pathogen resistance maybe develops (Stewart *et al*., 2014). Applications are made in autumn and spring as band sprays directed at the soil at the base of the canes.

Another management tool is soil solarization, which employs solar radiation to heat soil under a transparent plastic film to temperatures that are detrimental to soilborne pathogens (Pinkerton *et al*., 2009). Solarization targets mesophilic organisms, which include most plant pathogens and pests, without destroying thermo- tolerant fungi and *Bacillus* spp. (Pinkerton *et al*., 2009).

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Raspberry genotypes originating from breeding programs around the world have been selected for having high to moderate levels of disease resistance to *P. rubi* (Pattison & Weber 2005). Direct involvement of antibiotics in biocontrol has been proven in recombinant *Streptomyces melanosporofaciens* strains developed by intraspecific protoplast fusion (Agbessi *et al*., 2003).

EPPO Standard PM 4/10 Certification scheme for *Rubus* describes the production of certified pathogen-tested material (EPPO, 2009).

Phytosanitary risk

Raspberry root rot was a major reason for the introduction of a statutory certification scheme in Scotland in 1982. EPPO Standard PM 4/10 (EPPO, 2009) emphasises the importance of excluding *P. rubi* and other *Phytophthora*

species from certified raspberry material. In many certification schemes micropropagation is used for rapid multiplication of stocks, and is widely regarded as a safe tool for the provision of healthy planting material (Anderson, 1980). The raspberry pathogen is a potential hazard where soils remain cool and damp for some part of the year. It presents a serious danger to all parts of the EPPO region where raspberries are grown and is still of relatively limited distribution.

PHYTOSANITARY MEASURES

To prevent the introduction and spread of *P. rubi*, import requirements for raspberry plants for planting apply worldwide. *P. rubi* was long considered a variety of *P. fragariae*, therefore controlling legislation developed for *P. fragariae* was also intended to be applicable to this pathogen, although the greater capital investment involved in raspberry production, and the losses which raspberry root rot can cause, makes the need for such legislation pressing. EPPO has not yet recommended any requirements for control of *P. rubi*, though the EPPO recommendations for certification of *Rubus* planting material (EPPO, 2009) could provide an adequate basis to ensure that raspberry plants imported through this scheme are free from *P. rubi*. Phytosanitary certificates are required for imported raspberry plants and examination of stocks must be undertaken in most countries where the presence of the disease has become significant.

REFERENCES

Agbessi S, Beausejour J, Dery C & Beaulieu C (2003) Antagonistic properties of two recombinant strains of *Streptomyces melanosporofaciens* obtained by intraspecific protoplast fusion. *Applied Microbiology and Biotechnology* **62**, 233–238.

Anderson WC (1980) Tissue culture propagation of red and black raspberries, *Rubus idaeus* and *R. occidentalis*. *Acta Horticulturae* **112**, 13–20.

Barritt BH, Crandall PC & Bristow PR (1981) Red raspberry clones resistant to root rot. *Fruit Varieties Journal* **35**, 60-62.

Boesewinkel HJ (1982) A list of 142 new plant disease recordings from New Zealand and short notes on three diseases. *Australasian Plant Pathology* **11**, 40-43.

Bonants PMJ, van Gent-Pelzer MPE, Hooftman R, Cooke DEL, Guy DC & Duncan JM (2004) A combination of baiting and different PCR formats, including measurement of real-time quantitative fluorescence, for detection of *Phytophthora fragariae* in strawberry plants. *European Journal of Plant Pathology* **110**, 689–702.

Brasier CM, Cooke DEL & Duncan JM (1999) Origin of a new Phytophthora pathogen through interspecific hybridization. *Proceedings of the National Academy of Sciences USA* **96**, 5978-5883.

Bristow PR, Daubeny HA, Sjulin TM, Pepin HS, Nestby R & Windom GE (1988) Evaluation of *Rubus* germplasm for reaction to root rot caused by *Phytophthora erythroseptica*. *Journal of the American Society for Horticultural Science* **113**, 588-591.

Brunner-Keinath S & Seemüller E (1992) On the diagnosis of phytophthora root rot of raspberry, *Nachrichtenblatt des Deutschen Pflanzenschutzdienstes* **44**, 179-182.

Converse RH & Schwartze CD (1968) A root rot of red raspberry caused by *Phytophthora erythroseptica*. *Phytopathology* **58**, 56-59.

Cooke DEL, Drenth A, Duncan JM, Wagels G & Brasier CM (2000) A molecular phylogeny of *Phytophthora* and related Oomycetes. *Fungal Genetics and Biology* **30**, 17–32.

Daubeny HA (1987) 'Chilliwack' and 'Comox' red raspberries. *HortScience* **22**, 1343-1345.

Duncan JM, Kennedy DM & Seemüller E (1987) Identities and pathogenicities of *Phytophthora* spp. causing root rot

of raspberry. *Plant Pathology* **36**, 276-289.

Duncan JM & Kennedy DM (1989) The effect of waterlogging on phytophthora root rot of red raspberry. *Plant Pathology* **38**, 161-168.

Duncan JM, Kennedy D & Seemüller E (1987) Identities and pathogenicities of *Phytophthora* spp. causing root rot of raspberry. *Plant Pathology* **36**, 276-289.

EPPO (2009), EPPO Standards - Schemes for the production of healthy plants for planting - PM 4/10(2) Certification scheme for *Rubus*, *EPPO Bulletin* **39**, 271-277

Erwin DC & Ribeiro OK (1996) *Phytophthora Diseases World- wide*. APS Press, St. Paul, Minnesota (US).

Gigot J, Walters TW & Zasada IA (2013) Impact and occurrence of *Phytophthora rubi* and *Pratylenchus penetrans* in commercial red raspberry (*Rubus idaeus*) fields in northwestern Washington. *International Journal of Fruit Science* **13**, 357-372.

Graaberg M (1994), Raspberry root rot in Sweden. *Växtskyddsnotiser* **58**, 116-117.

Heiberg N (1995) Control of root rot of red raspberries caused by *Phytophthora* fragariae var. *rubi*. *Plant Pathology* **44**, 153-159.

Jung T, Horta Jung M, Scanu B, Seress D, Kovács GM, Maia C, Pérez-Sierra A, Chang TT, Chandelier A, Heungens K, van Poucke K, Abad-Campos P, Léon M, Cacciola SO & Bakonyi J (2017) Six new *Phytophthora* species from ITS Clade 7a including two sexually functional heterothallic hybrid species detected in natural ecosystems in Taiwan. *Persoonia* **38**, 100–135.

Liao Y, Smyth GK & Shi W (2014) featureCounts: an efficient general purpose program for assigning sequence reads to genomic features. *Bioinformatics* **30**, 923–930.

Liao F, Huang GM, Zhu LH, Lv D, Zhang D, Luo JF & Li GR (2019). Quadruplex PCR detection of three quarantine Phytophthora pathogens of berries. *European Journal of Plant Pathology* volume **154**, 1041–1049.

Maloney KE, Wilcox WF & Sandford JC (1993) Raised beds and Metalaxyl for control of Phytophthora root rot in raspberries. *HortScience* **28**, 1106 - 1108.

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

Pattison JA & Weber CA (2005) Evaluation of red raspberry cultivars for resistance to Phytophthora root rot. *Journal- American Pomological Society* **59**, 50–56

Pinkerton JN, Bristow PR, Windom GE & Walters TW (2009) Soil solarization as a component of an integrated program for control of raspberry root rot. *Plant Disease* **93**, 452–458

Seemüller E, Duncan JM, Kennedy DM & Riedel M (1986) A *Phytophthora* sp. causing root rot of raspberry. Nachrichtenblatt des Deutschen Pflanzenschutzdienstes **38**, 17-21.

Stammler G, Seemüller E & Duncan JM (1993) Analysis of RFLPs in nuclear and mitochondrial DNA and the taxonomy of *Phytophthora fragariae*. *Mycological Research* **97**, 150-156.

Stewart JE, Kroese D, Tabima J, Larsen MM & Grünwald JN (2014) Pathogenicity, fungicide resistance, and genetic variability of *Phytophthora rubi* isolates from raspberry (*Rubus idaeus*) in the western United States. *Plant Disease*, **98**, 1702–1708.

Tabima JF, Coffey MD, Zazada IA & Grünwald NJ (2018) Populations of *Phytophthora rubi* show little differentiation and high rates of migration among states in the Western United States. *Molecular Plant Microbe Interaction* **31**, 614-622.

Washington WS (1988) *Phytophthora cryptogea* as a cause of root rot of raspberry in Australia; resistance of raspberry cultivars and control by fungicides. *Plant Pathology* **37**, 225-230.

Waterson JM (1937) A note on the association of a species of Phytophthora with a 'die- back' disease of the raspberry. *Transactions of the Royal Society of Edinburgh* **32**, 251-259.

Wilcox WF (1989) Identity, virulence and isolation frequency of seven *Phytophthora* spp. causing root rot of raspberry in New York. *Phytopathology* **79**, 93-101.

Wilcox WF & Duncan JM (1993) *Phytophthora fragariae* Hickman var. *rubi* var. *nova*. *Mycological Research* **97**, 830.

Wilcox WF, Scott PH, Ham PB, Kennedy DM, Duncan JM, Brasier CM & Hansen EM (1993) Identity of a *Phytophthora* species attacking raspberry in Europe and North America. *Mycological Research* **97**, 817-831.

Wilcox WF, Pritts MP & Kelly MJ (1999) Integrated control of Phytophthora root rot of red raspberry. *Plant Disease* **83**, 1149-1154.

Wilcox WF & Cooke DEL (2017) Phytophthora root rot. In *Compendium of Raspberry and Blackberry Diseases and Pests*, 2nd ed (eds Martin RR, Ellis MA, Williamson B & Williams RN) American Phytopathological Society, pp. 52-56. St. Paul, MN (USA)

Wilcox WF & Latorre BA (2002) Identities and geographic distributions of *Phytophthora* spp. causing root rot of red raspberry in Chile. *Plant Disease* **86**, 1357-1362.

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Datasheet history

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CABI/EPPO (1992/1997) *Quarantine Pests for Europe (1st and 2nd edition)*. CABI, Wallingford (GB).

EPPO (1982) Data sheets on quarantine organisms, *Phytophthora fragariae*. *EPPO Bulletin* **12**(1), 105-111.

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