cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Peronospora sparsa Berk. 1862

downy mildew of cane fruit; downy mildew of rose

Current Pest Rating: C

Proposed Pest Rating: C

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

Comment Period: 07/10/2023 through 08/24/2023

Initiating Event:

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

History & Status:

Background:

Peronospora is a genus belonging to the class Oomycetes. The Oomycetes, also known as water molds, are a group of fungus-like microorganisms that belong to the kingdom Stramenopila. They are not true fungi but rather a distinct group within the eukaryotic domain. Oomycetes are primarily aquatic or semi-aquatic organisms and are commonly found in freshwater and marine environments. Oomycetes share some similarities with fungi in terms of their filamentous growth and ecological roles including in plant pathogenesis, but they differ significantly in their genetic and biochemical characteristics.

The downy mildews make up more than one third of the known oomycete species, with the largest oomycete genus, *Peronospora*, containing about 400 described species (Constantinescu 1991). The downy mildews are believed to have arisen from *Phytophthora*-like ancestors and were shown to be embedded within this genus (Göker et al. 2007). Members of the genus *Peronospora* are called downy mildews due to the fluffy, downy appearance of their spore-bearing structures. *Peronospora* spp. are

obligate parasites, infecting a wide range of plant hosts, including agricultural crops, ornamentals, and weeds, causing significant damage (Thines and Choi, 2016).

The life cycle of *Peronospora* involves both asexual and sexual reproduction. The asexual phase occurs under favorable conditions, typically characterized by high humidity and moderate temperatures. During this phase, specialized structures called sporangia are produced on the infected plant tissues. These sporangia release motile zoospores, which are capable of swimming through water films and infecting new plant tissues. Once a zoospore successfully enters a host plant, it germinates and forms a network of branched structures called hyphae, which spread throughout the plant tissues. Under certain conditions, sexual reproduction can also occur in *Peronospora*. This involves the fusion of two different mating types, resulting in the formation of oospores. Oospores are thick-walled structures that can survive in soil or plant debris for extended periods, allowing the pathogen to persist between growing seasons (Agrios, 2005).

Rose downy mildew was described in England in 1862 by Berkeley. The geographic origin of *P. sparsa* remains unknown, but its current wide distribution may reflect the extensive trading of rose propagation material during the latter half of the nineteenth century, which allowed the pathogen to spread between continents. It is worth noting that during this time, mycologists in Europe and America were actively publishing reports on plant pathogenic fungi. Therefore, the very early published reports of *P. sparsa* might reflect more the geographical areas where mycologists were active rather than the actual distribution of the pathogen. By the end of the nineteenth century, the diseases caused by *P. sparsa* were widespread with published reports from various European countries, and from the United States in the late 1800s (CABI, 2023).

The classification of *Peronospora sparsa* has caused some confusion in the past. As its symptoms are often not typical for downy mildew (Berkeley 1862) and sporulation is usually sparse—as the name already suggests—the pathogen is probably frequently overlooked or misidentified. There has been much debate regarding the host specificities of two close species, *P. sparsa* on roses and *P. rubi* on species of the genus Rubus (Breese et al., 1994). This differentiation was based on the observation that abundant oospores were found on *Rosa* but not on *Rubus*. However, when oospores were later discovered on *Rubus* as well, there was a suspicion that these pathogens might be the same species (Tate, 1981; Hall and Shaw, 1982; Hall, 1989).

While some studies suggested a rather broad host range for *P. sparsa*, including brambleberry (Breese et al., 1994), other studies came to the conclusion that distinct species exist on other hosts (Koponen et al., 2000). Molecular phylogenetic investigations also revealed an uncertain species delimitation (Choi et al. 2007; Voglmayr, 2003), but infection trials have shown that at least under artificial conditions, the host range of *P. sparsa* includes hosts apart from the genus *Rosa* (Breese et al., 1994). Most rose cultivars are susceptible to this pathogen (Schulz and Debener, 2009), but resistance to downy mildew is not amongst the most important traits of interest to breeders, even though *Peronospora sparsa* is difficult to control with fungicides. It is unclear, if rose downy mildew is seedborne, but the pathogen can be easily distributed with infected plants (Xu and Pettitt 2004).

Subsequent cross-inoculation experiments confirmed that isolates from *Rosa* and *Rubus* could infect both hosts under experimental conditions (Breese et al., 1994). As a result, it is now widely accepted that these two pathogens are indeed the same species. In terms of naming priority, *P. sparsa* takes precedence over *P. rubi* and is therefore the preferred name.

Hosts: Most of the hosts of *P. sparsa* are in the genus *Rosa* (roses) or *Rubus* (cane berries). *Prunus laurocerasus* (cherry laurel), *R. californica* (California rose), *R. canina* (dog rose), *R. centifolia* (cabbage rose), *R. chinensis* (China rose), *R. hybrida, R. rubiginosa* (sweet briar), *Rubus caesius* (dewberry), *R. canadensis, R. chamaemorus* (yellow berry), *R. fruticosus* (blackberry), *R. idaeus* (raspberry), *R. laciniatus* (cutleaf blackberry), *R. loganobaccus* (loganberry), *R. occidentalis* (black raspberry), *R. parviflorus* (thimbleberry), *R. procerus, R. spectabilis* (salmonberry) (CABI, 2023).

Symptoms: Symptoms of *Peronospora sparsa* infection on *Rosa* spp. include the appearance of yellowing leaves surrounding angular areas. These areas can range from green islands to lesions that turn purple or dark brown. In severe cases, heavily infected leaves may fall off, leading to rapid defoliation and reduced plant vigor. The fungus not only affects the leaves but also infects and causes purplish discoloration on stems, peduncles, calyxes, and petals (Baker, 1953). Sporulation, the production of spores, occurs on the underside of the leaves. Initially, the spore masses are white but gradually become light grey as they age. While some reports suggest that sporulation is sparse (which explains the specific epithet) (Chase and Daughtrey 2013), in certain conditions in California, it has been observed to be more abundant (Aegerter et al., 2003). It is important to note that sporulation can occur before the appearance of symptoms.

On *Rubus* spp., initially, downy mildew infection on leaves results in a light green to yellow discoloration on the upper leaf surface, which eventually progresses to red and purple hues. Mature lesions often exhibit angular shapes and are limited by the veins of the leaf. On the underside of the leaf, white to gray spore masses can be observed, but they may be sparse and challenging to detect. When primocanes (first-year canes) are systemically infected by downy mildew, they tend to be stunted and exhibit red streaks on the side that faces the sun. The terminal leaves of these canes may also display a reddish coloration. Infected fruits appear dull, lacking luster and turgidity, and they tend to dry out rapidly; berries with these symptoms are referred to as “dry berries”. Early infection of green fruit leads to premature reddening, shriveling, and hardening. Fruit infection occurring later in the season results in shriveling, drying, and the splitting of the fruit into two parts. Downy mildew-infected pedicels (stalks attaching the fruit) become dry and red (Koike et al., 2018).

Transmission: Peronospora sparsa primarily spreads through the dispersal of its spores: oospores, sporangia, and zoospores. Rainfall or irrigation can play a significant role in the spread of *P. sparsa*. When water droplets impact infected plant surfaces, spores present in the downy growth on the undersides of leaves can be dislodged and splashed onto nearby healthy plants. This water splash dispersal mechanism allows the spores to reach new hosts and initiate infection. Although not as significant as rain splash, wind can also contribute to the spread of *P. sparsa*. Air currents can carry spores over short distances, especially in the presence of gusty winds. Airborne spores are produced during cool, wet nights and are disseminated by wind. Human activities, such as pruning, trimming, or

handling infected plant material, can inadvertently transfer *P. sparsa* spores to healthy plants. *Peronospora sparsa* can persist and survive on infected plant debris, fallen leaves, or infected stems. Weed growth and dense canopies create humid environments that favor the development of the disease on suckers. (CABI, 2023; Koike et al., 2009).

The latent period of *P. sparsa* on roses was remarkably short. The ideal temperature for colonization was found to be around 20 or 25°C. Under these temperature conditions, a significant portion of the leaves displayed symptoms merely 4 days after inoculation, and sporulation occurred as early as 5 days after inoculation. In Kern County, where the average daily temperature in March and April typically ranges between 10 and 20°C, symptoms would manifest, and sporulation would commence within a narrow timeframe of just 4 to 7 days, making control very difficult (Aegeter et al., 2003). *Peronospora sparsa* can systemically colonize the stem cortex and can occur in crown and root tissues of rose (Aegeter, et al., 2002).

Damage Potential: A large percentage of the bare-root roses produced in the United States are grown in Kern County, in the San Joaquin Valley. The field production system has faced sporadic but persistent challenges with rose downy mildew caused by *P. sparsa* since the early 1990s. Infected leaves exhibit rapid abscission, leading to significant defoliation and a decline in plant vigor (Salgado-Salazar et al., 2018). Within the first two months after budbreak, rootstock cuttings that are defoliated by downy mildew may struggle to root, resulting in reduced crop yield. In mature bushes, the decreased vigor can impede the canes' growth, preventing them from reaching the desired diameter for top-grade classification, and rendering such plants unharvestable. In cases where the stems are severely affected by the disease, dieback of young canes has been observed, likely due to the invasion of secondary pathogens like *Botrytis* spp. (Aegerter et al., 2003). Perennating crown infections (surviving over seasons inside the plant tissues) have been implicated source of inoculum for epidemics the following season necessitating a reduction in inoculum through treatment of mother plants to delay the start of a mildew outbreak or reduce its severity (Aegerter et al., 2002).

Worldwide Distribution: A listing of the geographic distribution of *P. sparsa* is found at CABI Invasive Species Compendium (https://doi.org/10.1079/cabicompendium.39730), with the pathogen occurring in all major regions of the world where roses are grown, including North America, Asia, Africa, Europe, Oceania, and South America.

Official Control: *Peronospora sparsa* is a quarantine pest in Israel and a regulated non-quarantine pest in Switzerland and United Kingdom. It is listed on the USDA PCIT's harmful organisms list for Chile, Guatemala, Honduras, India, Nicaragua, Panama, and Paraguay (USDA PCIT, 2023).

California Distribution: Widespread along the coast, in the Bay Area, and in the Central Valley (French, 1989; CDFA PDR Database, 2023).

California Interceptions: none

The risk *Peronospora sparsa* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** Downy mildew is most prevalent during wet weather at temperatures of 65 °F (18 °C). For roses, the critical number of hours of leaf wetness for disease development was an average of 8.4 h per day over 10 days. Many parts of California are too hot and dry for disease development, but where canopies are dense, or when plants are systemically infected, disease outbreaks are rapid and severe.

   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 limited to roses, cane berries, and cherry laurels

   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:** This pathogen has multiple types of spores, including swimming zoospores and thick-walled resting oospores. It spreads with wind and rain.

   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 pathogen is a serious but sporadic problem for both rose and cane berry growers. Its annual occurrence and severity depends upon prevailing weather patterns (Aegerter et al., 2003). Where there are outbreaks, it causes significant financial and crop losses. It can be very severe in greenhouses if humidity is not controlled. Systemic infection of dormant stock requires clean propagation and proper sanitation techniques to prevent spread to new plantings.

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

   Economic Impact: A, B, C

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:** Native *Rubus* and *Rosa* can be hosts of this pathogen. It has a very significant impact on cultural practices, ornamental plantings, and home gardens.

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

Environmental Impact: A, 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 *Peronospora sparsa:* 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.

Peronospora sparsa has been in California, largely unregulated, for decades. It has been spread inadvertently with planting material.

Evaluation is 'high'.

Score: -3

-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* ***= 9***

Uncertainty:

There are questions about the degree of genetic relatedness of pathogen isolates collected from rose, cane berries, and cherry laurel, and questions about the natural movement of genotypes from host to host.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for ***Peronospora sparsa*** **is C.**

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***Comment Period: 07/10/2023 through 08/24/2023**

***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: C