CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Bremia lactucae Regel 1843

downy mildew of lettuce

Current Pest Rating: C

Proposed Pest Rating: C

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

Comment Period: 12/02/2022 through 01/16/2023

Initiating Event:

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

History & Status:

Background:

Downy mildews are a group of obligately biotrophic Oomycetes in the family Peronosporaceae. Oomycetes are traditionally treated within mycology, although they are not related to true fungi (kingdom Fungi) but belong to the kingdom Chromista (Straminipila) which also contains the chromistan (heterokont) algae. (All species of this family are pathogens of higher plants and there are numerous economically important plant pathogens on grain crops, vegetables, field crops, ornamentals, shrubs, and vines. Downy mildews are most damaging when there is a thin layer of water on the plant tissues along with a high level of relative humidity during mild or warm, but not extremely hot, weather. Infection can quickly result in significant losses.

Downy mildews cause blights, attacking young, delicate green leaves, twigs, and fruit and often cause rapid and severe losses. If infection takes place at the seedling or young plant stage, the pathogen causes systemic shoot infections. When older plants are attacked, they may develop localized infected areas, or they may allow the oomycete to spread into young tissues and become locally systemic

(Agrios, 2005). An early repot of this pathogen in California was made from 1919 when Milbrath (1923) reported that with just a few important commercial lettuce varieties under production, all of which were susceptible, downy mildew was widespread, with 40% of the fields had levels infection called "severe".

Lettuce (*Lactuca sativa* L.) ranks second in total production among all vegetables in the United States, surpassed only by tomato. According to production statistics compiled by the USDA's National Agricultural Statistics Service and released by CDFA, lettuce is the fifth largest commodity in California, with a 2021 value over $2B. Roughly 75 percent of the nation's lettuce and leafy greens are grown in California. There are three main growing regions: the Central Coast, which includes both the Salinas Valley and the Santa Maria/Oxnard region, is the largest with 75 percent of production for the state, the Desert region is the second largest with 20 percent of production, and the Central Valley – which acts as a seasonal transition region between the other two – produces the final 5 percent. (https://www.cdfa.ca.gov/Statistics/).

Bremia lactucae is one of the most intensely studied downy mildews and is often used as a model system for studying pathogenesis and resistance genes (Michelmore and Wong, 2008; Michelmore et al., 2009). In the past, Phytopathologists used a broad species concept for downy mildew groups, which lead to the classification *Bremia lactucae* as a broad host range pathogen. At one time it was described from more than 200 species of the Asteraceae family. Early molecular phylogenetic studies concluded there were several highly supported lineages within the *B. lactucae* complex. These matched partially to formae speciales introduced by Skidmore and Ingram (1985), which had been developed from former species that were brought into *B. lactucae.* Recent phylogenetic investigations revealed that *B. lactucae* is restricted to cultivated lettuce, *Lactuca sativa*, and its wild progenitor, *Lactuca serriola* (prickly lettuce) (Runge et al., 2021).

Lettuce downy mildew is the most important disease of lettuce worldwide, requiring 90% of the fungicide applications to control, and with reports of losses up to 100% (Wu et al., 2001). *Bremia lactucae* is a complex organism, consisting of multiple races (pathotypes) in California. New races continue to evolve, and new resistance genes are introduced by lettuce breeders (Parra et al., 2021).

Hosts: Lactuca sativa (garden lettuce) and *Lactuca serriola* (prickly lettuce).

Symptoms: Symptoms appear initially as chlorotic yellow spots on the underside of the leaf and light green to yellow angular spots on the corresponding upper side of the leaf. During early stages of disease development, lesions are often delineated by leaf veins, giving infections an angular appearance. Under favorable environmental conditions, a white, fluffy, cotton-like growth from the formation of sporangia will appear on the lower leaf surface within 24 to 48 hours following initial symptom development. Over time, these lesions turn brown and dry up. Severely infected plants may die. Although the symptoms are usually most severe on mature outer leaves, on occasion, the pathogen can become systemic, causing dark discoloration of stem tissues, infecting lettuce heads internally and even roots (Koike and Turini, 2017; Rodrigues-Porto et al., 2021).

Transmission: Bremia lactucae spreads with spores called sporangia. The sporangia are borne on small, treelike structures called sporangiophores that emerge through stomata on the leaf surface. Spores are normally formed at night and are released during the day. Sporangia may then move either with rain splash/sprinklers, or wind-disseminated to healthy host tissue. Although rain-splash dissemination normally ranges from centimeters to a meter, sporangia may be windblown over distances of kilometers and remain viable. Spores of *B. lactucae* may infect, colonize, and produce repeating generation of spores in as few as five to seven days. Five to seven hours of high humidity (near 100% RH) or leaf wetness are required for successful infection and sporulation. In addition to sporangia, thick-walled sexual spores called oospores, are also formed by *B. lactucae*. These oospores allow the pathogen to survive in the absence of a suitable host and serve as initial inoculum for subsequent epidemics (Koike and Turini, 2017; Rodrigues-Porto et al., 2021).

Damage Potential: Commercial crisphead, leaf, and cos lettuce types are all susceptible to downy mildew, but varieties show a differential response depending on the genotypes of the pathogen and the presence of resistance genes in the host. If the lettuce plants are infected while still in the seedbed, the pathogen often destroys from 40 to 90% of the young plants, causing heavy or total losses. The severity of disease depends on the prolonged presence of wet, cool weather during which the downy mildew sporulates profusely, and can spread into and rapidly kill young soft tissues. In cool, wet weather, downy mildews are often uncontrollable, slowed or stopped only when the weather turns hot and dry. Since the discovery of systemic fungicides, disease control has improved considerably, although downy mildews are often very difficult to control, leading to disease modeling and advisory systems to improve fungicide applications (Wu et al., 2001).

Primarily a foliar disease of a crop grown for its leaves, the disease has a direct effect on both yield and the quality of lettuce. Although direct yield losses in the field at harvest may be substantial, the impact is often exacerbated by significant postharvest losses that occur during transportation or storage. In addition to the postharvest losses, lesions may facilitate infections by other pathogens, such as the fungus *Botrytis cinerea*, or they may enhance opportunities for foodborne pathogens, such as *Escherichia coli* or *Salmonella enterica* (Rodrigues-Porto et al., 2021).

Worldwide Distribution: Africa: *Algeria, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Libya, Morocco, South Africa, Tanzania, Tunisia, Zambia.* Americas: *Argentina, Brazil, Canada, Chile, Cuba, Guatemala, Guyana, Jamaica, Mexico, Panama, Peru, United States of America, Uruguay, Venezuela.* Asia: *China, Indonesia, Iran, Iraq, Israel, Japan, Kazakhstan, Democratic People's Republic of Korea, Republic of Korea, Kyrgyzstan, Lebanon, Pakistan, Philippines, Taiwan, Turkmenistan, Uzbekistan*. Europe: *Austria, Belgium, Bulgaria, Cyprus, Czechia, Denmark, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Malta, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Spain, Sweden, Switzerland, Turkey, United Kingdom*. Oceania: *Australia, New Zealand* (EPPO, 2022).

Official Control: *Bremia lactucae* is on the USDA's Phytosanitary Certificate Issuance and Tracking System's harmful organism report for Honduras, Mexico, and Nicaragua (USDA PCIT, 2022).

California Distribution: Contra Costa, Imperial, Kern, Mendocino, Monterey, Orange, San Benito, San Luis Obispo, Santa Barbara, and Santa Cruz counties (CDFA PDR database, 2022).

California Interceptions: none

The risk *Bremia lactucae* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** Lettuce is a cool season crop with distinct temperature requirements. The optimal growing temperatures are 73°F (23°C) during the day and 45°F (7°C) at night. As an obligate biotroph, *Bremia lactucae* is likely to occur wherever lettuce can grow.

   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:** In the past, the host range was thought to be very large. Recent work has limited the host range to two *Lactuca* species.

   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 environmental conditions, this pathogen reproduces very rapidly and produces large epidemics. It is dispersed with air and water. It is not seed borne.

   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 downy mildew has been a major pathogen of lettuce in California for over 100 years. It impacts both the quantity and quality of lettuce crops. It is a quarantine pest in several countries.

   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: With the recent changes in the host range, the only non-crop host is *Lactuca serriola*, which is a non-native weed but very common in the lettuce production areas. Efforts in controlling this pathogen accounts for 90% of fungicide applications.

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

Environmental Impact: 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 *Bremia lactucae:* 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.

   This pathogen is widespread in all commercial lettuce production areas of California

   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:

   Final Score: *Score of Consequences of Introduction – Score of Post Entry Distribution and Survey Information* ***= 9***

Uncertainty:

None

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Bremia lactucae* is C.

References:

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Responsible Party:

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***Comment Period: 12/02/2022 through 01/16/2023**

***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
