California Pest Rating Proposal for

Monilinia fructigena Honey ex Whetzel 1945

Brown rot of fruit

Current Pest Rating: none

Proposed Pest Rating: A

Kingdom: Fungi, Phylum: Ascomycota,
Subphylum: Pezizomycotina, Class: Leotiomycetes,
Order: Helotiales, Family: Sclerotiniaceae

Comment Period: 06/20/2023 through 08/04/2023

Initiating Event:

This pathogen has not been through the pest rating process. Attestation of freedom from this pathogen is frequently requested on phytosanitary certificates for the export of host plants. The risk to California from *Monilinia fructigena* is described herein and a permanent pest rating is proposed.

History & Status:

Background:

Brown rot fungi are apothecial ascomycetes. The genus *Monilinia* belongs to the family Sclerotiniaceae and comprises approximately 25 species, the majority of which are plant pathogens with a necrotrophic lifestyle. Necrotrophic fungi were initially considered to act by degrading plant tissue with the secretion of cell wall-degrading enzymes and toxins in an indiscriminate manner (van Kan, 2006). More recently it has been shown that many necrotrophic fungi actively manipulate the programmed cell death machinery of the host for their own benefit, by secreting effector proteins and/or secondary metabolites (Garcia-Benitez et al., 2019; Lee et al., 2010).

Monilinia spp. produce ascospores (sexual spores) on the upper surface of a cup- or disc-shaped structure known as an apothecium. Apothecia can be 5-20 mm in diameter and are produced on mummified fruit that have fallen to the ground. Although commonly described in textbooks, apothecia are rarely observed in the field. Conidia (asexual spores) have anamorphs in *Monilia* and are produced

on sporodochia. The conidia are hyaline, lemon-shaped, and produced in a moniloid manner, resembling a string of beads with constricted ends. Under ideal conditions, conidia will germinate within 3 to 5 hours, and extensive mycelial growth can occur in ripe fruit within 24 hours (Dowling et al., 2019).

There are three well-studied species, *Monilinia fructigena*, *M. laxa*, and *M. fructicola.* All three can cause brown rot and blossom blight; all three can result in significant fruit rots in the field, and additional fruit losses postharvest. *Monilinia fructicola* is widespread in the United States, North America, South America, South Africa, Australia, and occurs in parts of Europe. *Monilinia laxa* is primarily a problem in the Pacific Northwest. *Monilinia fructigena* causes brown rot and blossom blight in pome fruit and stone fruit of the Rosaceae family and is an important pathogen with a broad host range. Both *M. fructicola* and *M. laxa* are established in California and periodic disease outbreaks are highly associated with weather conditions favorable for infection (Gubler et al., 2009).

Monilinia fructigena is widespread in Europe, Asia (e.g., Near East, Far East, India), northern Africa, and some parts of South America, and it is a quarantine pathogen in Canada, USA, Australia, Mexico, and New Zealand (CABI, 2023). It is not known to be in North America. *Monilinia fructigena* is more common in pome fruit and has lower incidence in stone fruit (Vilanova et al., 2021).

Hosts: Actinidia arguta (tara vine), *Amelanchier canadensis* (thicket serviceberry), *Berberis* (barberries), *Capsicum* (peppers), *Chaenomeles japonica* (Japanese quince), *Cornus mas* (cornelian cherry*), Corylus avellana* (hazel), *Cotoneaster divaricatus*, *Crataegus laevigata, Cydonia* (quince), *Cydonia oblonga* (quince), *Diospyros kaki* (persimmon), *Eriobotrya japonica* (loquat), *Ficus carica* (common fig), *Fragaria* (strawberry), *Fragaria ananassa* (strawberry), *Malus domestica* (apple), *Malus purpurea, Malus scheideckeri, Malus sieversii, Malus sylvestris* (crab-apple tree), *Mespilus germanica* (medlar), *Prunus* (stone fruit), *Prunus armeniaca* (apricot), *Prunus avium* (sweet cherry), *Prunus cerasifera* (myrobalan plum), *Prunus cerasus* (sour cherry), *Prunus domestica* (plum), *Prunus dulcis* (almond), *Prunus mandshurica, Prunus persica* (peach), *Prunus persica* var. *nucipersica* (nectarine), *Prunus salicina* (Japanese plum), *Prunus spinosa* (blackthorn), *Prunus triloba* (Rose tree of China), *Psidium guajava* (guava), *Pyrus* (pears), *Pyrus betulaefolia, Pyrus communis* (European pear), *Pyrus elaeagrifolia, Pyrus pyrifolia* (Oriental pear tree), *Pyrus ussuriensis* (amur pear), *Rhododendron* (Azalea), *Rosa* (roses), *Rosa hybrida, Rubus* (blackberry, raspberry), *Rubus occidentalis* (black raspberry), *Solanum lycopersicum* (tomato), *Sorbus* (rowan), *Sorbus acuparia, Vaccinium* (blueberries), and *Vitis vinifera* (grapevine) (CABI, 2023; Farr and Rossman, 2023).

Symptoms: Following infection from ascospores in the spring, young flowers wither, spurs and leaves collapse, and small cankers may form on shoots. If they are girdled by the growth of mycelium, the shoots will die. In years with continuous rains in the spring, leaves can also be infected. Leaf lesions are brown, water soaked, and under favorable environmental conditions, sporulation of the pathogen can develop on the leaf surfaces.

Most parts of the blossoms are susceptible to attack, including the sepals, petals, anthers, and stigmas. Infected blossoms can collapse rapidly, followed by wilting of terminal leaves, and blighting of whole

twigs. Especially on stone fruit, gum may be exuded from the infected shoots. Gray to brown tufts of spores produced in sporodochia found on infected tissues. Infected blossom parts may cling to enlarging fruit, and with moisture, produce more spores of the pathogen, thus serving as sources of inoculum for infection of the developing green fruit. Infections of green fruit begin as soft water-soaked, dark areas. Rot first develops in clustered fruit, in fruit contact spots, and insect- or wind-damaged fruit. Clustered fruit have characteristics that are more favorable for disease development. For instance, fruit-to-fruit contact surfaces have microcracks, thinner cuticles, and favorable micro-environmental conditions, all predisposing fruit to infection (Dowling et al., 2019; CABI, 2023).

Quiescent infections can be seen as small black specks on the fruit surface. It is also possible to have latent infections that are invisible (Michailides et al., 2000; Sinclair and Cerkauskas, 1996). Depending on the timing and the weather conditions, infections decay either green or mature fruit. Brown rot infections of mature fruit begin as soft water-soaked areas that turn dark brown, with the surface eventually becoming covered with sporodochia, usually emerging through lenticels or cracks on the fruit skin. Tight fruit clusters where fruit are touching, hail, insect, and bird wounds all predispose fruits to brown rot (Michailides, 2007). Infected fruit shrivel and dry on the trees and become "mummies". During fall and winter rains, some "mummies" will drop on to the ground and serve as a source of apothecia in spring.

Transmission: Conidia of the *Monilia* anamorph are dispersed by wind and rain-splash, and, where apothecia are formed, ascospores will also be wind-disseminated (Batra, 1991). The pathogen can survive long periods of adverse environmental conditions as mycelium within mummified fruits, twigs, cankers, and other infected tissues. The primary source of spring inoculum is derived locally from overwintering fruit mummies and branch cankers, remaining on standing trees and the orchard floor. Warm temperatures with moist or humid conditions trigger the production of ash-gray-brown colored sporodochia (tufts of conidiophores) bearing conidia (asexual spores) in chains. Rapid mycelial growth is possible in as little as 24 hours and conidia germination can be observed in 3-5 hours (Dowling et al., 2019).

Insects including wasps, beetles, flies, and butterflies, have been identified as vectors of *Monilinia* species., Any insect that visits uninfected fruit after visiting infected fruit could serve as a vector. Lack (1989) specifically observed bees, wasps, fruit flies and syrphid flies on apple fruit infected with *M. fructigena*. Birds may also be vectors and birds cause wounds to apple fruit in orchards affected by *M. fructigena* (Byrde and Willetts, 1977)

The most likely means of accidental introduction of *M. fructigena* into North America would be infected fruit brought in commercially or by individuals from other continents. Also, trees or scions with twig blight infections that do not go through standard phytosanitary channels could carry the fungus over great distances to susceptible hosts in California (CABI, 2023).

Damage Potential: Worldwide, brown rot is the most important disease risk for stone fruits in warm, humid climates. It is the primary disease for which fungicides are applied to many fruits. On apples, fruit rot is very common and destructive; sometimes the fungus spreads into branches from the fruit and gives rise to long lasting cankers. A symptom referred to as 'black apple' may also develop. The

color of the rot is initially brown, but becomes jet black (Byrde and Willetts, 1977). The skin of the apple then has a shiny smooth surface, and shrinkage of the apple tissue is insignificant until late in black apple development. This condition is mostly found in stored fruits. Fruit rot is common in pear and plum, but less severe in peach, nectarine, and apricot than other species of *Monilinia* (CABI, 2023).

Worldwide Distribution: Africa: Egypt, Morocco; Asia: Afghanistan, China, India, Iran, Israel, Japan, Korea Dem. People's Republic, Korea, Republic, Lebanon, Nepal, Taiwan, Uzbekistan; Europe: Armenia, Austria, Azerbaijan, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Georgia, Germany, Greece, Hungary, Ireland, Italy, Italy, Latvia, Lithuania, Luxembourg, Moldova, Netherlands, Norway, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye, Ukraine, and United Kingdom (EPPO, 2023)

Official Control: *Monilinia fructigena* is on the EPPO's A1 list for Argentina, Brazil, and Chile; the A2 list for Jordan, and the Comite Regional de Sanidad Vegetal del Cono Sur (COSAVE); and is a quarantine pest for Canada, Mexico, New Zealand, and the United States of America (EPPO, 2023). It is on the USDA PCIT's harmful organisms list for Argentina, Brazil, Canada, Chile, Costa Rica, Egypt, Jordan, Mexico, New Zealand, Nicaragua, Peru, Syrian Arab Republic, and Taiwan (USDA PCIT, 2023). It is a USDA Regulated Pest, meaning it would be subject to rejection if found at a port or during border inspections.

California Distribution: none

California Interceptions: none

The risk *Monilinia fructigena* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** Blossom infection is highly dependent on wetness duration and temperature. Although widespread outbreaks of brown rot of over large parts of the state rarely occur, disease development on an orchard scale depends on the pathogen's inoculum potential, microclimatic conditions, and cultural practices. Warm, wet, or humid weather during the 2-to-3-week period prior to fruit harvest increases disease severity because it increases both the level of inoculum and the amount of infection. If wet weather extends into the harvest period, fruit loss can be severe (Michailides, et al., 2007; Dowling et al., 2019).

   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:** Under suitable environmental conditions, *M. fructigena* will infect not only all cultivated drupaceous and pomaceous species, but also many other members of the Rosaceae. The main commercial crops that are hosts to *M. fructigena* include apple, pear, quince, plum, sweet cherry, sour cherry, peach, nectarine, and apricot. Wild hosts may be sources of inoculum if located near orchards (Zehr, 1982).

Evaluate the host range of the pest.

Score: 3

- 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:** Brown rot can produce huge numbers of airborne conidia and can cause severe epidemics when weather is conducive.

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:** The pathogen can potentially infect all aerial host plant parts, such as blossoms, buds, shoots, twigs, branches, peduncles, leaves, and fruit. In the first half of the 20th century, before effective fungicides were developed and without knowledge of integrated pest management, rapid and nearly total crop loss was possible for very susceptible stone fruit (Agrios, 2005; Ogawa et al., 1995). It is a quarantine pest in the United States.

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:** Wild hosts in Rosaceace and Pomaceae have been recorded in Europe. If strains that are aggressive on pome fruit are introduced to California, the need for fungicide to protect those hoses may increase. If a first detection for North America is made, the USDA may want to attempt eradication.

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

Environmental Impact: A, 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: 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 *Monilinia fructigena:* High

Add up the total score and include it here. **14**
-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 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* ***= 14***

Uncertainty:

California already has 2 important species that cause brown rot diseases with nearly identical symptoms: *M. fructicola* and *M. laxa.* Separating these species from *M. fructigena* requires an expert diagnostician. The arrival of *M. fructigena* may be difficult to recognize unless it shows increased virulence on pome fruit.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for ***Monilinia fructigena*** **is A.**

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Responsible Party:

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***Comment Period: 06/20/2023 through 08/04/2023**

***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
