**CALIFORNIA PEST RATING PROPOSAL**

***Colletotrichum fioriniae* (Marcelino & Gouli) Pennycook 2017**

**Anthracnose Fruit and Crown Rot of Strawberry**

**Current Rating:** B

**Proposed Rating:** C

**Initiating Event:** Strawberry growers in Oxnard reported plant stunting and collapse in February 2021. We traveled to Oxnard and visited 9 ranches to collect samples. We returned to our lab in Watsonville and through careful observation we noted small darkened lesions along the outer margin of the crowns. We surface disinfected portions of the symptomatic crowns and plated the tissue onto semi-selective media for the isolation of several plant pathogens. We obtained numerous pure cultures which looked slightly different from the Colletotrichum isolated from earlier outbreaks. The colony pigment of these cultures on PDA was pink with gray aerial mycelium in compact tufts on the topside of the dish and pink with dark flecking on the bottom side of the plate. Many of these pure cultures appeared to be "chromogenic," meaning they change color over time after isolation from light red to pink to gray. We conducted Koch's postulates with several different selections of strawberry genetics by inoculating cut roots with an inoculum suspension and observing the plants for two weeks in a research greenhouse. After symptom expression we were able to re-isolate the pathogen from the diseased plants.

Upon learning of the CDFA rating of a B for this pathogen and based on our reading of the published literature and discussions with plant pathologists at the University of California Riverside and Davis, as well as discussions with University of Florida plant pathologists, we informed CDFA plant pathology colleagues of these findings. Most recently we worked with the Ventura County Agricultural Commissioner's office to have them collect official samples from 6 farms in Oxnard and Camarillo 3 weeks in a row through the end of May 2021.

**History & Status:**
CDFA wrote a California Pest Rating Proposal and published it in 2019, however we only became aware of it in March 2021. CDFA reported that their rating was based on an initial interception in January 2019 of leaf and twig samples of California coffeeberry (*Frangula californica*) showing symptoms of twig dieback collected from a regional park in Alameda County and sent to the CDFA Plant Pathology Lab for diagnosis, which identified the associated pathogen as *Colletotrichum fioriniae*. Prior to this detection, *C. fioriniae* had been reported from California in 2017 on pistachios (Lichtemberg et al 2017) in Glenn County. CDFA assigned a temporary Z rating for a generally distributed pathogen of economic and environmental importance.

Background: *Colletotrichum fioriniae,* like many species in the genus Colletotrichum, is a hemibiotrophic fungus which means it often has a biotrophic, and then later necrotrophic phase causing disease. In addition, often the fungus can be quiescent in a wide range of the host plant tissues it infects (flowers, fruit, petioles, crowns, roots). It is also reported as being an endophyte. It is known to have a very wide host range (Baroncelli et al 2015, R. Baroncelli, pers. comm.) and causes anthracnose symptoms of leaf spot and fruit rot in its host plants (Farr and Rossman, 2019). The pathogen belongs to the morphologically and physiologically variable *C. acutatum* species complex from which it is molecularly differentiated from other species of the

complex (Damm et al., 2012). The name *C. fioriniae* was based on the original name of strains of the fungus that were isolated from an epizootic infection of the exotic scale insect *Fiorinia externa* in New England. Strains of *C. fioriniae* were found to occur widely as an endophyte in the host plant of the sap-sucking scale insect and believed to act as natural protectants against plant feeding insects (Damm et al., 2012).

In California, pistachios showing severe anthracnose symptoms of black, sunken, and circular lesions in fruit, leaves, and rachises, were observed in Glenn County in 2010 and 2016. Subsequently, *Colletotrichum fioriniae* was isolated from those pistachio trees and, in 2017, this pathogen was reported for the first time in California (Lichtemberg et al., 2017). Then as a follow up to this finding, in a 2019 survey of 7 California counties, it was then reported to have been found in two counties, both Glenn and Butte County, by the same researchers (Lichtemberg et al., 2019b).

*Hosts: As listed in the CDFA 2019 PRA: Acacia acuminata* (mangart/jam), *Actinidia chinensis* (kiwi), *Allium amperoprasum* (wild leek/broadleaf wild leek), *Anemone* sp., *Camellia sinensis* (tea plant), *Capsicum annuum* (bell pepper), *Capsicum frutescens* (chili pepper), *Capsicum* sp., *Carica papaya* (papaya), *Cinnamonmum subavenium*, *Citrus* sp., *C. unshiu* (satsuma mandarin), *Corylus avellana* (common hazel), *Eustoma grandiflorum* (lisianthus), *Ficus virens* (white fig), *Fiorinia externa* (elongate hemlock scale), *Fiorinia* sp., *Fragaria x ananassa* (strawberry), *Ilex serrata-verticillata* ('Sparkleberry'), *I. verticillata* (winterberry holly), *Juglans regia* (English walnut), *Liriodendron tulipifera* (tulip tree/tulip poplar), *Lycium barbarum* (matrimony vine), *L. chinense* (Chinese boxthorn), *Magnolia* sp. *Malus domestica* (apple), *Malus* sp., *Mangifera indica* (mango), *Mangifera* sp., *Michelia champaca* (Joy perfume tree), *Nandina domestica* (heavenly bamboo), *Olea europaea* (olive), *Persea americana* (avocado), *Persea* sp., *Pinus radiata* (Monterey pine), *Pistacia vera* (pistachio), *Prunus armeniaca* (apricot), *P. persica* (peach), *Pyrus communis* (common pear), *Rhododendron* sp., *Rubus* sp., *Salvia leucantha* (Mexican bush sage), *Solanum melongena* (eggplant), *Toxicodendron radicans* (eastern poison ivy), *Tulipa* sp., *Vaccinium corymbosum* (northern highbush blueberry), *V. myrtillus* (bilberry/whortleberry), *Vaccinum* sp., *Vitis* sp., *Vitis vinifera* (grape) (Farr and Rossman, 2019).

*Symptoms*: In general, *Colletotrichum*-infected host plants exhibit symptoms of anthracnose which include dark brown leaf, stem and fruit spots and wilting of leaves often resulting in dieback and reduction in plant quality. In pistachio, *C. fioriniae* exhibits anthracnose symptoms of black, sunken, and circular lesion in fruit, leaves, and rachises (Lichtemberg et al., 2017). Strains of *C. acutatum* that were later identified as *C. fioriniae* have been implicated in fruit rot of cranberry and blueberry in northern USA and in British Columbia (Damm et al., 2012). Members of the *Colletotrichum acutatum* species complex have been observed to infect many parts of the strawberry plant. Fully open flowers are the most susceptible to Flower blight which also affects flower buds, pedicels and peduncles. Anthracnose is a disease of the petiole, runner, and fruit lesions, and causes stunting, yellowing, and wilting and collapse of plants in warmer, wetter climates, such as in Oxnard and in Florida. Diseased petioles and runners have dark brown or black, lens-shaped, sunken spots. When crown tissue is infected it decays, which causes the entire plant to wilt and die. Anthracnose fruit rot is another disease caused by *C. acutatum* in production areas with warm, rainy weather. Fruit at any stage of development can be affected. Small, sunken, oval-to-round brown spots (on green fruit) or black spots (red fruit) develop and expand. Under high humidity, salmon or orange-colored spores can form on the lesions of the fruit, petioles, and runners. Decayed fruit tissue becomes firm and dry overtime.

*Disease cycle:* It is quite likely that *Colletotrichum fioriniae* has a similar life cycle to that of other *Colletotrichum* species and survives between crops during winter as mycelium on plant residue in soil, on infected plants, and on seeds. During active growth, the pathogen produces masses of hyphae (stromata)

which bear conidiophores, on the plant surface. Conidia (spores) are produced at the tips of the conidiophores and disseminated by wind, rain, cultivation tools, equipment, and field workers.

Conidia are transmitted to host plants. Humid, wet, rainy weather is necessary for infection to occur. These requirements in particular may limit the occurrence of the pathogen in California fields and subsequently, the pathogen may be more of a problem under controlled environments of greenhouses. Conidia germinate, penetrate host tissue by means of specialized hyphae (appressoria) and invade host tissue.

*Dispersal and spread*: Wind, wind-driven rain, cultivation tools, and human contact.

*Damage Potential:* Anthracnose disease caused by *Colletotrichum fioriniae* can result in reduced plant quality and growth. Estimates of yield/crop loss due to this pathogen have not been reported.
Nursery production of potted host plants or in greenhouses are particularly at risk as nursery conditions are often conducive to infection by *Colletotrichum* species. In cultivated fields, disease development may be sporadic as it is affected by levels of pathogen inoculum and environmental conditions and host susceptibility.

*PRP for Colletotrichum fioriniae*

Worldwide Distribution: *Asia*: China, Japan, Malaysia, South Korea, Turkey; *Europe*: Belgium, Croatia, France, Italy, Poland, Portugal, Slovenia, United Kingdom; *North America*: United States; *South America*: Brazil; *Oceania*: Australia, New Zealand (Farr and Rossman, 2019; Liu et al., 2016; Munda, 2016; Pszczókowska et al., 2016; Sun et al., 2012; Zhu et al., 2015). Within the United States, *Colletotrichum fioriniae* has been reported from California, Hawaii, Kentucky, Maryland, Massachusetts, Michigan, New York, Ohio, and Virginia (Farr and Rossman, 2019).
Official Control: None reported.

California Distribution: CDFA reported in 2019 (Chitamber 2019) its occurrence in Alameda and Glenn Counties. However, further research was conducted including a survey of 7 counties in 2019 and *C. fioriniae* was reported in both Butte and Glenn counties (Lichtemberg et al 2019b, Marzall-Pereira et al 2020). We have just submitted 6 official samples with the help of the Ventura County Ag Commissioner from the Oxnard and Camarillo areas. It is widely known that members of the *C. acutatum* species complex have been present in numerous California counties for years, especially where nuts and tree fruit are produced, and also where strawberry nurseries produce planting stock, including Merced, Glenn, Butte and Tehama counties among others. As stated in the *C.acutatum* pest rating document, it is likely that this pathogen has been observed statewide, mainly in strawberries and other fruits (CDFA PDR database), as it is one of several species in the C.a. species complex.

Dr. Jim Adaskaveg has conducted research in almonds for the past 20 years, and more recently in strawberry on the C.a. species complex, and he thinks that members of the species complex like *C. fioriniae* likely have been present in California for years. He reported seeing “chromogenic” isolates in his Förster & Adaskaveg 1999 paper, and also in his Haack et al 2018 paper, and personally via phone (pers. comm, March 2021). He intends to conduct research into the phylogenetic relationships on almond and strawberry using newer molecular multi-locus sequencing to better understand the distribution of these pathogens in California (pers. comm.).

Dr. Themis Michailides also confirms (via email pers. comm May 24, 2021) that he believes C. fioriniae. has been in California almond and pistachio orchards as a member of the C.a. species complex for many years.

California Interceptions: There have been no interceptions of plants infected with *Colletotrichum fioriniae* (see: 'Initiating Event').

The risk *Colletotrichum fioriniae* would pose to California is evaluated below.

**Consequences of Introduction:**

**1) Climate/Host Interaction:** *Colletotrichum fioriniae* has already been detected in pistachio and coffeeberry plants cultivated in three counties. However, considering its wide range of host plant, most of which are present in California, it is possible for the pathogen to have a larger distribution, but limited due to the requirement of prolonged, wet weather conditions for the pathogen's development

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 of *Colletotrichum fioriniae* is very diverse and includes several plant families.

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 Dispersal Potential:** The pathogen has high reproductive potential and conidia are produced successively. They are transmitted by wind, wind-driven rain, cultivation tools, and human contact. Conidial germination and plant infection require long, wet periods.

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:** Under suitable climates, the pathogen could lower plant growth and value and trigger the loss of markets.
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. - Low (1) causes 0 or 1 of these impacts.

**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:** The pathogen could significantly impact cultural practices, home gardening or ornamental plantings.
Evaluate the environmental impact of the pest on California using the criteria below.
**Environment Impact: 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: 2**
- 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 *Colletotrichum fioriniae*:**

Add up the total score and include it here. **(Score): 13**
-Low = 5-8 points
-Medium = 9-12 points
**-High = 13-15 points**

Total points obtained on evaluation of consequences of introduction to California =

**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 High.*** Presently, *Colletotrichum fioriniae* is reported in more than two contiguous or non-contiguous suitable climate/host areas. Therefore, it is given a score of -3 in this category.

**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 = 10***
**Uncertainty:**
**Conclusion and Rating Justification:** Based on the evidence provided above we propose that **the rating for C. *fioriniae should be changed to a C*.**

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