CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Alternaria arborescens E.G. Simmons 1999

Current Pest Rating: Z

Proposed Pest Rating: C

Kingdom: Fungi, Phylum: Ascomycota,
Subphylum: Pezizomycotina, Class: Dothideomycetes,
Subclass: Pleosporomycetidae, Order: Pleosporales,
Family: Pleosporaceae

Comment Period: 06/10/2021 through 07/25/2021

Initiating Event:

In October 2020, a sample of kangaroo paws (*Anigozanthos* sp.) with leaf spots were collected during a regulatory nursery inspection by an agricultural inspector in Santa Cruz County. The samples were sent to CDFA's Plant Pest Diagnostics Center at Meadowview. Plant pathologist Cheryl Blomquist isolated *Alternaria arborescens* from the spots. She confirmed her diagnosis with DNA sequencing and assigned a temporary Z rating. The risk to California from *A. arborescence* is describe herein and a permanent rating is proposed.

History & Status:

Background: *Alternaria* is a ubiquitous ascomycete fungal genus that includes saprobes, endophytes and pathogens associated with a wide variety of substrates including seeds, plants, agricultural products, animals, soil, and the atmosphere. Identification of *Alternaria* species has historically been based on morphological characteristics, including cultural morphology, size and shape of conidia, mycelial growth, sporulation patterns, and branching patterns of conidial chains (Simmons, 1999). Although major sections within the genus can be separated using these characters, the high degree of variability makes this approach difficult, especially when trying to separate closely related species.

In recent years, DNA-based studies have revealed multiple non-monophyletic genera within the *Alternaria* complex and within the *Alternaria* species clades. The genus is currently divided into dozens of sections, and most small-spored *Alternaria* species with concatenated conidia including *A.*

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arborescens belong to section *Alternata*, which has the type species *Alternaria alternata* (Lawrence et al., 2016; Woudenberg et al., 2013, 2015).

Alternaria arborescens as described by Simmons (1999) has also been found to be a species complex and subsequently the following three species (in addition to *A. arborescens*) have been described, identified, and separated out: *A. cerealis*, *A. geophila*, and *A. senecionicola* (Woudenberg et al., 2015). The type strain of *A. arborescens* is from California where it was found to be a causal agent of stem canker of tomato.

Hosts: Acer truncatum (maple), *Anigozanthos* sp. (kangaroo paw), *Avena sativa* (oat), *Brassica napus* (canola), *Brassica rapa* var. *parachinensis* (white cabbage), *Brassica* sp., *Cakile maritima* (sea rocket), *Corylus avellana* (hazelnut), *Daucus carota* (carrot), *Diplotaxis tenuifolia* (wall rocket), *Eruca sativa* (arugula), *Helianthus annuus* (sunflower), *Hordeum vulgare* (barley), *Ilex verticillate*, *Juglans regia* (walnut), *Lycopersicon esculentum* (tomato), *Malus domestica* (apple), *Ocimum basilicum* (basil), *Oryza sativa* (rice), *Panicum virgatum* (switch grass), *Phoenix dactylifera* (date palm), *Pistacia vera* (pistachio), *Prunus* sp., *Punica granatum* (pomegranate), *Pyrus communis* (pear), *Salvia elegans* (pineapple sage), *Solanum lycopersicum* (tomato), *Solanum tuberosum* (potato), *Symphyotrichum novi-belgii* (daisy), *Triticum aestivum* (wheat), *Triticum durum* (wheat), *Triticum* sp., *Vitis* sp., *Vitis vinifera* (grape) (Farr and Rossman, 2021; CDFA PDR database).

Symptoms: On pistachio, *A. arborescens* is one of three species along with *A. alternata* and *A. tenuissima* that cause a disease called late blight. The symptoms are black angular or circular lesions on leaves of both male and female trees. Black lesions are also present on petioles and main veins of leaf blades. On immature fruit, the symptoms appear as small black lesions about 1 mm in diameter. On mature fruit, both small (1–2 mm) and large (5 mm) black lesions are present on the epicarp, usually surrounded by a reddish-purple margin. Black spores develop in the center of the leaf lesions when humid conditions prevail in orchards.

Pistachio leaf infections can cause severe premature defoliation and create problems during shaking the trees at harvest. Multiple lesions on leaves and fruit cause leaf blight and deterioration of hulls, respectively. Deterioration of hulls results in shell staining. Excessive growth of the fungus can also invade the kernel, resulting in kernel decay (Michailides and Teviotdale, 2014).

On blueberries, *Alternaria* spp. including *arborescens*, *alternata*, and *tenuissima* cause a ripe fruit rot. The first symptom is a shriveling or caving-in of the side of the berry, that develops as the fruit begins the ripen. This deformity is generally located near the flower end. The damaged area may be covered with a blackish or dark greenish mass of spores. Although berries may be dry in the field, the rot can become watery when harvested fruit is stored. Infected berries also tend to break open easily. Sometimes leaf lesions occur and are circular to irregularly shaped, tan to gray, about 0.5 cm or less in diameter, and surrounded by a reddish-brown border. In most cases only lower leaves are affected (Pscheidt and Ocamb, 2019; Wang et al., 2020).

On tomatoes, symptoms of *Alternaria* stem canker, caused by *A. arborescence* and *A. alternata*, appear on stems, leaves, and fruit. Dark brown to black cankers with concentric zonation occur on stems near

the soil line or aboveground. Cankers enlarge, girdle the stem before harvest, and kill the plants. Vascular tissue about 2 inches above and below the cankers exhibit brown streaks. Dark brown to black areas of dead tissue between leaf veins are caused by a toxin produced by the fungus. Dark brown sunken lesions with characteristic concentric rings develop on green fruit either on plants or during postharvest transit of ripening fruit (Davis et al., 2013).

On pomegranates, Alternaria fruit rot can be caused by *A. arborescens* or *A. alternata* and is also known as black heart. The pathogens can grow inside the fruit without external decay symptoms. Infected fruit generally are lighter in weight and the rind may be slightly off-color, such as a paler red, and may show some brownish-red discoloration. In the later stages of infection, arils show a brown decay and black sporulation can be seen inside the fruit. In advanced stages of internal decay, the fruit's exterior shows some shriveling (Adaskaveg and Michailides, 2018).

There are several diseases of citrus caused by *Alternaria* spp. including leaf and fruit spots, and fruit rot, also known as black rot. Alternaria rot is common as a stem-end rot but disease can also develop at the blossom end or at wounds on the fruit, and symptoms may develop in the field before harvest or during storage (Timmer et al., 2003). In California, mandarins suffer a post-harvest rot of fruit caused by *A. alternata* and *A. arborescens* (Wang et al., 2020).

Transmission: Alternaria arborescens and related species can be present on plant surfaces and in dying or dead tissue of plants. The pathogens overwinter on plant debris in or on the soil and in mummified fruit. The spores are airborne and can be carried to the flowers or wounded fruit with soil dust. Infection can also occur when plants contact infested soil. Free water is necessary for spore germination and infection. Disease spread is favored by rains, dew, and overhead irrigation. Symptoms develop 7 to 10 days after inoculation and develop most rapidly at temperatures around 25°C (Davis et al., 2013). Infections may also start from insect and bird punctures on fruit. While research on pomegranates in the San Joaquin Valley suggests that the petal fall stage is the most susceptible to infection, infection can occur throughout the bloom and fruit development periods (Adaskaveg and Michailides, 2018).

For blueberries, the fungus overwinters as mycelium and spores in old, dried-up berries, dead twigs from the previous season's crop and on other plant debris. Infections can occur any time between late bloom through fruit maturity. Infections remain quiescent (latent) until fruit ripens. The disease often is not seen in the field but develops in storage or in transit to market (Pscheidt and Ocamb, 2019).

Damage Potential: Alternaria arborescens can produce several mycotoxins, such as alternariol, alternariol monomethyl ether and tenuazonic acid and phytotoxins such as the AAL toxins (Vaquera et al., 2014). Mycotoxins are a risk to human and animal health. When they are present in relatively high concentrations, they cause acute illnesses. There are also serious health effects from chronic, subacute dosages of mycotoxins in food and feed.

Estimated losses from *Alternaria* spp. are usually less than 1% but can be up to 6% on pomegranates (Adaskaveg and Michailides, 2018). For California blueberries, Zhu and Xiao (2015) describe fruit rot

caused by *Alternaria* spp. as one of the most import factors affecting the post-harvest quality and shelf life of the fruit.

With pistachios, Michailides and Teviotdale (2014) describe Alternaria late blight as a problem in orchards irrigated by sprinklers or flooding, with low soil infiltration, and those irrigated with microsprinklers, particularly in lower areas where relative humidity is high and dew formation is frequent during late August and September. There are latent infections on leaves and fruit, and the disease is more severe on leaves from fruit-bearing shoots than those without fruit. Losses occur mainly because of fruit staining, kernel decay, and from early defoliation. The pathogen can colonize the inner surface of the shell and endocarp, causing moldy nuts.

For mandarins, Wang et al. (2020) described Alternaria rot as an emerging disease on mandarin fruit because of recent changes in postharvest handling. They suggest that inoculum of *Alternaria* spp. from one crop could also serve as potential inoculum for other susceptible crops grown in the close vicinity.

Alternaria spp. are wound pathogens, requiring an injury to the peel in order to infect, and that to reduce potential Alternaria infection leading to postharvest fruit rot, care should be taken to minimize injuries to the rind of the fruit during harvest and postharvest handling. A recent survey for postharvest diseases on mandarins in California showed that Alternaria rot accounted for up to 83% of the total rots on the harvested fruit in the field bins before storage and 15% of the total rots on the stored fruit (Saito and Xiao, 2017).

Worldwide Distribution: Africa: *South Africa, Tunisia*. Americas: *Chile, Mexico, United States* (California, Massachusetts, Oklahoma, Washington). Asia: *China, India, Oman, Pakistan, Turkey*. Europe: *Belgium, Cyprus, Denmark, France, Greece, Italy, Netherlands, Spain, Switzerland*. Oceania: *Australia, New Zealand*.

Official Control: None

California Distribution: There is one CDFA sample collected during a nursery inspection in Santa Cruz County (see 'initiating events'), although in the past, many small spored *Alternaria* spp. could have been identified as being part of the *A. alternata* species complex. There are published reports in literature from University of California researchers of detections of *A. arborescens* going back at least 20 years. UC reports are from Fresno, Kern, San Joaquin, San Luis Obispo, Siskiyou, Tulare and Yolo counties in commercial sunflowers, potato, tomato, carrot, blueberries, pomegranates, citrus, pistachios, and almonds.

California Interceptions: None

The risk *Alternaria arborescens* would pose to California is evaluated below.

Consequences of Introduction:

1. **Climate/Host Interaction:** This pathogen has a wide host range and will likely be found anywhere its hosts can grow, but disease will likely be more severe in areas that are wetter or have higher humidity. For example, Alternaria stem canker on tomato is more common near the coast.

   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 this pathogen is high, including multiple families of plants, plus it can survive in soil and plant debris.

   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:** *Alternaria* spp. produce very large numbers of multi celled conidia that are relatively resistant to drying and melanized to resist degradation by UV light. Spores travel with air currents, infested soil, and crop debris.

   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:** *Alternaria arborescens* and *A. alternata.* appear to be the most prevalent species associated with Alternaria diseases in various crops in the Central Valley of California.

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

   Economic Impact: A, B
   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: **2**
- 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:** None have been reported

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

Environmental Impact:
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: 1
- 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 *Alternaria arborescens:* Medium

Add up the total score and include it here. **11**
-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 '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* ***= 8***

Uncertainty:

Often multiple species of *Alternaria* are found co-infecting a single host, making it difficult to determine the relative contribution to pathogenicity of each individual species. It is likely that *Alternaria arborescens* as described by Simmons (1999) will continue to undergo taxonomic revisions.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Alternaria arborescens* is C.

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Zhu, X.Q. and Xiao, C.L., 2015. Phylogenetic, morphological, and pathogenic characterization of **Alternaria** species associated with fruit rot of blueberry in California. Phytopathology, 105(12), pp.1555-1567.

Responsible Party:

Heather J. Scheck, Primary Plant Pathologist/Nematologist, CDFA/PHPPS ECOPERS, 2800 Gateway Oaks Suite 200, Sacramento, CA 95833 Phone: (916) 654-1017, permits[@]cdfa.ca.gov.

***Comment Period: 06/10/2021 through 07/25/2021**

***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
