

California Pest Rating Proposal for *Diplodia bulgarica* Phillips, Lopes & Bobev 2012

Current Pest Rating: Z

Proposed Pest Rating: B

Domain: Eukaryota, Kingdom: Fungi,
Phylum: Ascomycota, Subphylum: Pezizomycotina,
Class: Dothideomycetes, Order: Botryosphaerales,
Family: Botryosphaeriaceae

Comment Period: 07/06/2023 through 08/20/2023

Initiating Event:

In March 2023, a Plant Pathologist from the University of California contacted the California Department of Food and Agriculture to report the detection of a fungal pathogen, *Diplodia bulgarica*. He made the detection from apple trees showing symptoms of cankers and dieback and was unaware of any previous California records. Sonoma County agricultural officials collected an official sample from the same orchard and submitted it to CDFA's Plant Pest Diagnostics lab at Meadowview. CDFA Plant Pathologist Wei Belisle isolated *Diplodia bulgarica* in culture from the cankers and confirmed her diagnosis by PCR and gene sequencing. From the same samples, she also detected *D. seriata*, a common apple canker pathogen of very similar etiology. She assigned an unofficial Z rating to *D. bulgarica*. The risk to California from *Diplodia bulgarica* is described herein and a permanent rating is proposed.

History & Status:

Background:

Apples are grown on nearly 12,000 acres in California with a total value in 2021 of \$51M. There are five major apple growing regions. Historically, apple production was limited to the coastal mountains north and south of the San Francisco Bay, in the Sierra foothills east of Sacramento, and in the Southern California mountains. As lower chill varieties have become more popular, coastal apple production expanded in Santa Cruz and San Luis Obispo in the Central Coast region. Today the major apple

production areas are in the San Joaquin Valley with Kern, Fresno, San Joaquin, and Madera counties being the leading producers (https://www.cdfa.ca.gov/Statistics/PDFs/2022_Ag_Stats_Review.pdf).

Diplodia is a large genus with more than 1200 species (Crous et al., 2006). The genus was introduced by Montagne (1834) with *D. mutila* as the type species. *Diplodia* spp., like other members of the family Botryosphaeriaceae, are pathogens, endophytes, and saprophytes on a wide range of mainly woody hosts worldwide. There are relatively few distinguishing morphological features that can be used to separate *Diplodia* spp. Until relatively recently, species were identified based on conidia colors and features and on host association, which resulted in a proliferation of species names. Many of the named *Diplodia* species are likely to be synonyms. In the 21st century, the genus has received support from cladistic analysis of DNA sequence data (Crous et al., 2006; Dissanayake et al., 2016; Phillips et al., 2012).

Diplodia cankers typically affect a single branch and then gradually move to other branches and into the trunks, weakening and reducing vigor of the tree over time. *Diplodia* spp. can cause “soft rots” of wood that affect the surface layers of branches and trunks where they are maintained with an environment of a continuously high moisture substrates. Soft-rot fungi utilize both polysaccharides and lignin for pathogenesis. They invade wood through rays or vessels, from where they grow into the adjacent tracheids and invade cell walls. Within the cell wall they produce conical or cylindrical cavities parallel to the orientation of the microfibrils, with progressing decay. The most severe infections of this disease follow environmental stresses to the trees such as drought or cold injury (Agrios, 2005).

Three species of *Diplodia*, known to be pathogens of apples and other members of Rosacea, have been found recently in California: *D. bulgarica*, *D. malorum*, and *D. seriata*. *Diplodia malorum* and *D. seriata* have recently received California pest ratings of B <https://blogs.cdfa.ca.gov/Section3162/?p=6807>; and C <https://blogs.cdfa.ca.gov/Section3162/?p=9201>, respectively.

All three species cause apple diseases including black rot, frog-eye leaf spot, post-harvest fruit rots, and cankers (Phillips et al., 2012). The first report of *D. seriata* in California was made by Crespo et al. in 2017 in San Joaquin County, and the first detection of *D. malorum* was made by CDFA plant pathologist Suzanne Rooney-Latham from Santa Clara County in 2018 (PDR database, 2023). This pest rating describes the detection of *D. bulgarica* in Sonoma County by CDFA plant pathologist Wei Belisle (see ‘initiating events’). It is less likely that these three species are recently arrived in California, and more likely that our ability to identify them as distinct species has improved.

Phillips et al. (2012) studied *Diplodia* isolates, mainly from apples, in terms of morphology and phylogenetic position based on nucleotide sequence data from ITS and EF1- α loci. *Diplodia bulgarica* sp. nov. was described in 2012 by Phillips et al. from isolates collected from *Malus sylvestris* in Bulgaria in 2005 with these notes: “this species is morphologically distinct from other *Diplodia* species reported from apples. Conidia are shorter and wider than both *D. intermedia* and *D. malorum*. Furthermore, the conidia are distinctive in that they become pale brown soon after they are formed. Phylogenetically this species is closely related to *D. cupressi* and ‘*B. tsugae*’ (Alvez et al., 2006; Phillips et al., 2013).

Hosts: Malus domestica (apple), *Pyrus communis* (European pear) (Berger et al., 2021; Farr and Rossman, 2023).

Symptoms: The most striking symptoms of *Diplodia* infection are black cankers on the trunks and limbs of trees. The bark of infected apple limbs becomes slightly sunken, often in an oval shape, with reddish-brown lesions under the bark. Cankers range from only a superficial roughening of the bark to deeper necrotic cracks with discolored vascular cambium that extends up to 12". The cankers are often associated with bark injuries such as cracks, pruning wounds, or sun damages. In older cankers, black pycnidia sometimes break through the bark near the canker. As cankers age, the bark separates from the underlying wood and can fall to the ground. Some trees become girdled by the cankers and die (Berger et al., 2021; Pscheidt and Ocomb, 2023).

This pathogen also causes gummosis, dieback, and twig blight symptoms on apples (Abdollahzadeh, 2015). Leaf symptoms include the development of a leaf spot with a purple margin and tan center commonly referred to as "frog-eye leafspot". Infected leaves fall prematurely from the tree. A blossom end fruit rot may also develop starting as a purple spot with a red ring. Lesions may also occur at insect injuries. The fruit lesions in Washington did not develop concentric rings but were light-to-dark-brown with defined margins. Pycnidia may develop in the lesions. In advanced stage the fruit was completely rotted, spongy to firm, and light brown. Fruit mummifies and remain attached to the tree. Post-harvest fruit rot has also been reported as slightly sunken and light to dark brown lesions that ranged from 7 to 25 mm in diameter with defined margins (Eken, 2022).

Transmission: Like *Diplodia* spp. on other hosts, the fungus survives from season to season in cankers or mummified fruits and enters branches through wounds and possibly natural openings. Warm and wet weather favors spore dispersal, infection, and disease development. Asexual fruiting bodies (pycnidia) are produced and will continue to produce spores for about two years. On branches, pycnidia are in black masses of fungal tissue (stromata) on and embedded in the bark. Spore production and germination are favored by moisture. During winter rainfall, spores are released, and wounds made by winter pruning provide infection sites (Smith et al., 2014).

Damage Potential: This pathogen has been called a threat to the apple industry in Iran (Abdollahzadeh, 2015), India (Nabi et al., 2020), and Germany (Berger et al., 2021). Damage symptoms include canker, dieback, twig blight, and fruit rot, in the field and post-harvest. It is the main causal agent of apple tree decline in Iran, where popular cultivars including Golden Delicious, Red Delicious, Granny Smith, Braeburn, and Gala were all found to be susceptible, and its effects were called "devastating" (Hanifeh et al., 2017).

Worldwide Distribution: Germany, India, Serbia, Turkey, United States (California).

Official Control: None

California Distribution: There has been one detection in an apple orchard in Sonoma County.

California Interceptions: none

The risk *Diplodia bulgarica* would pose to California is evaluated below.

Consequences of Introduction:

1) Climate/Host Interaction:

Diplodia spp. require rain and wet conditions for spore production, dissemination, and infection. California weather conditions are generally favorable for only short periods in the winter and spring, but commonly occur in the parts of the state where apples and pears are produced.

Evaluate if the pest would have suitable hosts and climate to establish in California.

Score: 3

- 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 *Malus* and *Pyrus* spp.

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 suitable environmental conditions, the pathogen spreads with airborne spores. *Diplodia* spp. produce large numbers of conidia, but they require wet weather to spread and infect. They also require a wound or natural opening and are unable to directly infect intact bark.

Evaluate the natural and artificial dispersal potential of the pest.

Score: 2

- 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:

Economic losses have been reported from cankers on apple and pear trees and decay on fruit. Epidemics are often associated with pre-existing or concurrent environmental stresses and wounding from pruning. During times of environmental stress, branch cankers and dieback can have a significant impact on tree health and yield. It's likely there will be differences in susceptibility between varieties of apples. It is likely that it will be able to infect apple fruit in California. Winter pruning practices will need to be modified when this pathogen is present.

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

Economic Impact: A, B, D

- 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:** This disease could have significant impacts if tree pruning is done during wet weather.

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

Environmental 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 *Diplodia bulgarica*: 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.

One official sample has been collected in Sonoma County. It is likely established, at least locally.

Evaluation is 'Low'.

Score: -1

-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 = 10

Uncertainty:

Co-infection of *D. bulgarica* with closely related species also known to cause disease on apple including *D. malorum* and *D. seriata*, along with other fungi in the Botryosphaeriaceae, complicate damage estimates from this species. Therefore, there is some uncertainty regarding the significance of *D. bulgarica*, alone, as a disease of apples.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Diplodia bulgarica* is **B**.

References:

- Abdollahzadeh, J., 2015. *Diplodia bulgarica*, as a new pathogen and potential threat to the apple industry in Iran. *Phytopathologia Mediterranea*, 54(1), pp.128-132.
- Agrios, G. N., 2005. *Plant Pathology*, 5th Edition. Elsevier Academic Press. 922 pg.
- Alves, A., Correia, A., and Phillips, A.J., 2006. Multi-gene genealogies and morphological data support *Diplodia cupressi* sp. nov., previously recognized as *D. pinea* f. sp. *cupressi*, as a distinct species. *Fungal Diversity*, 23(1), pp.1-15.
- Berger, J., Zegermacher, K., and Zgraja, G., 2021. First report of *Diplodia bulgarica* causing black canker on apple (*Malus domestica*) and pear (*Pyrus communis*) in Germany. *New Disease Reports*, 43(1), pp.NA-NA.
- Crespo, M., Moral, J., Michailides, T. J., and Trouillas, F.P., 2017. First report of black rot on apple fruit Caused by *Diplodia seriata* in California. *Plant Disease*, 102(4). doi.org/10.1094/PDIS-07-17-1023-PDN
- Crous, P.W., Slippers, B., Wingfield, M.J., Rheeder, J., Marasas, W.F., Philips, A.J., Alves, A., Burgess, T., Barber, P., and Groenewald, J.Z., 2006. Phylogenetic lineages in the Botryosphaeriaceae. *Studies in mycology*, 55(1), pp.235-253.
- Dissanayake, A.J., Phillips, A.J.L., Li, X.H. and Hyde, K.D., 2016. Botryosphaeriaceae: Current status of genera and species. *Mycosphere*, 7(7), pp.1001-1073.
- Eken, C., 2022. *Diplodia bulgarica*, cause of postharvest rot on apples in Turkey. *Australasian Plant Disease Notes*, 17(1), p.15.
- Farr, D.F., and Rossman, A.Y. *Fungal Databases*, U.S. National Fungus Collections, ARS, USDA. Retrieved June 5, 2023, from <https://nt.ars-grin.gov/fungaldatabases/>
- Hanifeh, S., Zafari, D., and Soleimani, M.J., 2017. Reaction of some apple cultivars to *Diplodia bulgarica* in Iran. *Mycosphere*, 8(2), pp.1253-1260.
- Nabi, S.U., Raja, W.H., Mir, J.I., Sharma, O.C., Singh, D.B., Sheikh, M.A., Yousuf, N., and Kamil, D., 2020. First report of *Diplodia bulgarica* a new species causing canker disease of apple (*Malus domestica* Borkh) in India. *Journal of Plant Pathology*, 102, pp.555-556.
- Phillips, A.J.L., Lopes, J., Abdollahzadeh, J., Bobev, S., and Alves, A., 2012. Resolving the *Diplodia* complex on apple and other Rosaceae hosts. *Persoonia-Molecular Phylogeny and Evolution of Fungi*, 29(1), pp.29-38.
- Phillips, A.J.L., Alves, A., Abdollahzadeh, J., Slippers, B., Wingfield, M.J., Groenewald, J.Z., and Crous, P.W., 2013. The Botryosphaeriaceae: genera and species known from culture. *Studies in Mycology*, 76(1), pp.51-167.
-

Pscheidt, J.W., and Ocamb, C.M., senior editors. 2023. Pacific Northwest Plant Disease Management Handbook [online]. Corvallis, OR: Oregon State University. <https://pnwhandbooks.org/plantdisease> (accessed June 2, 2023).

Smith, R.J., Bettiga, L.J., and Gubler, W.D., 2014. Botryosphaeria dieback. UC IPM Pest Management Guidelines: Grape UC ANR Publication 3448.

Responsible Party:

Heather J. Scheck, Primary Plant Pathologist/Nematologist, CDFA/PHPPS ECOPERS, 1220 N St Rm 221, Sacramento, CA 95814 Phone: (916) 654-1017, [permits\[@\]cdfa.ca.gov](mailto:permits[@]cdfa.ca.gov).

***Comment Period: 07/06/2023 through 08/20/2023**

***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](mailto: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: B
