CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Phytophthora palmivora (E.J. Butler) E.J. Butler 1919

Coconut budrot

Current Pest Rating: C

Proposed Pest Rating: B

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

Comment Period: 07/18/2022 through 09/01/2022

Initiating Event:

Phytophthora palmivora has been assigned an informal C-rating by the California Department of Food and Agriculture (CDFA), Plant Health and Pest Prevention Services, but has not previously gone through the current pest risk analysis process. The risk to California from *P. palmivora* is described herein and a permanent rating is proposed.

History & Status:

Background: Phytophthoras are filamentous, osmotrophic eukaryotes that resemble fungi morphologically but belong to the class Oomycota in the kingdom Stramenopila. The genus *Phytophthora* include some of the most destructive plant pathogens of agricultural crops, ornamental plants, and forests. The majority of the described *Phytophthora* species are soilborne and waterborne, primarily responsible for root and collar rots, and occasionally bleeding stem cankers. They infect through the release of biflagellate zoospores into soil or surface water. Airborne *Phytophthora* species produce almost exclusively caducous sporangia and primarily infect aerial parts of plants, causing leaf necroses, shoot blights, fruit rots, and bleeding bark cankers on stem and branches. Aerial infections occur through detached sporangia spread by wind and rain splash (Erwin et al., 1996).

In 1907 Butler originally described a new species, *Pythium palmivorum*, from palms and coconut. It was reclassified as *Phytophthora palmivora* by Reinking in 1923. The specific epithet originates from one of

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the tree species from which the pathogen was originally isolated, the Palmyra palm (*Borassus flabellifer*). The center of origin for this *Phytophthora* species is believed to be southeastern Asia (McHaw and Coffey, 1994).

The number of recognized *Phytophthora* species is rapidly increasing and currently includes more than 180 provisionally named species (Yang et al., 2017). With DNA sequencing, the taxonomic concept for the genus has evolved from one based on morphology to a molecular phylogeny-based system, and this work has increased our understanding of *Phytophthora* evolution and pathology.

The genus is currently organized into clades and subclades based on genetic relationships. Blair et al. (2008) produced a sophisticated phylogeny based on sequences of seven nuclear genetic markers. Their work divided 82 *Phytophthora* species into 10 phylogenetically well-supported clades. Correlations have been observed between molecular phylogenies, individual morphology, and physiological traits. Studies have indicated that species in individual clades or subclades are mostly identical in sporangial papillation, and optimum and maximum growth temperatures, and the evolution of several clades appears to be associated with host specialization (Cooke et al., 2000). *Phytophthora palmivora* is in clade 4 based on ITS sequences of genomic rDNA (Balci et al., 2008).

Phytophthora palmivora can attack more than 175 different host plants, including monocots and dicots, ranging from small vegetables to trees, in the tropics and subtropics, causing significant losses to production (Drenth and Guest 2013; Erwin and Ribeiro, 1996). *Phytophthora palmivora* attacks a wide range of different plant tissues from roots, trunks, stems, flowers, leaves, and fruits. While *P. palmivora* has a pan-tropical distribution, the damage it causes to agriculture in the tropics tends to be more intense than in the sub-tropics (Chee 1974; Erwin and Ribeiro, 1996).

In the tropics, *P. palmivora* is a damaging pathogen of important agronomic crops including cacao (*Theobroma cacao*), citrus (*Citrus* sp.), durian (*Durio zibethines*), jackfruit (*Artrocarpus heterophyllus*), rubber (*Hevea brasiliensis*), and several palm species including coconut (*Cocos nucifera*), and African oil palm (*Elaeis guineensis*). The damage from of *P. palmivora* on cacao, for example, has been well documented (Drenth and Guest 2013; Guest 2007), with an annual impact on the global industry of at least one billion U.S. dollars. It also causes bud rot in oil palm, where recent epidemics of bud rot have destroyed more than 70,000 ha of oil palms in Colombia (Torres et al., 2016).

Phytophthora palmivora was first found in California in greenhouses in San Francisco in 1947 attacking *Dieffenbachia picta* (Tompkins and Tucker, 1947). In 1974, a destructive disease of ivy (*Hedera helix*), found in potted greenhouse plants in Ventura, was confirmed to be caused by *P. palmivora* (Keim et al., 1976). Both occurrences were in humid, warm greenhouse conditions, which are favorable for the development foliar blight epidemics by *P. palmivora.*

Hosts: Actinidia deliciosa (kiwifruit), *Allium cepa* (onion), *Anacardium excelsum*, *Anacardium occidentale* (cashew nut), *Ananas comosus* (pineapple), *Annona cherimola* (cherimoya), *Areca catechu* (betelnut palm), *Artocarpus altilis* (breadfruit), *Artocarpus heterophyllus* (jackfruit), *Bactris gasipaes* (peach palm), *Borassus flabellifer* (toddy palm), *Caesalpinia pulcherrima* (peacock flower), *Carica papaya* (pawpaw), *Citrus aurantiifolia* (lime), *Citrus jambhiri* (rough lemon), *Citrus limonia* (mandarin

lime), *Citrus maxima* (pummelo), *Citrus reticulata* (mandarin), *Citrus unshiu* (satsuma), *Citrus volkameriana*, *Citrus* x *paradisi* (grapefruit), *Cocos nucifera* (coconut), *Coronilla valentina*, *Dodonaea viscosa* (switch sorrel), *Durio zibethinus* (durian), *Elaeis guineensis* (African oil palm), *Eustoma grandiflorum*, *Lisianthus* sp., *Ficus carica* (common fig), *Gossypium hirsutum*, *Grevillea alpina*, *Grevillea rosmarinifolia*, *Herrania* sp., *Hevea brasiliensis* (rubber), *Howea belmoreana*, *Lavandula angustifolia* (lavender), *Macadamia integrifolia* (macadamia nut), *Manihot esculenta* (cassava), *Manilkara zapota* (sapodilla), *Momordica charantia* (bitter gourd), *Myristica fragrans* (nutmeg), *Olea europaea*, *Olea europaea* subsp. *europaea* (European olive), *Oxypetalum coeruleum*, *Pachira aquatica* (pachira nut), *Persea americana* (avocado), *Petunia hybrida*, *Phoenix canariensis* (Canary Island date palm), *Piper nigrum* (black pepper), *Pistacia lentiscus* (mastic tree), *Pistacia vera* (pistachio), *Pittosporum, Pogostemon cablin* (patchouli), *Poncirus trifoliata* (trifoliate orange), *Punica granatum* (pomegranate), *Pyrus communis* (European pear), *Rosmarinus officinalis* (rosemary), *Salix babylonica* (weeping willow), *Sorghum halepense* (Johnson grass), *Telosma cordata*, *Tetragastris panamensis*, *Theobroma cacao* (cocoa), *Trachycarpus fortunei* (Chinese windmill palm), and *Zygopetalum maculatum* (CABI CPC, 2022).

Symptoms: *Phytophthora palmivora* is a hemibiotroph. Initially it is parasitic in living tissues and then continues to grow and sporulate in dead tissue. Infection begins when motile zoospores contact plant surfaces. The spores encyst, germinate, and form appressoria to penetrate the surface (Judelson and Blanco, 2005). Upon accessing plant tissues, the pathogen develops digit-like haustoria that protrude into living plant cells for the release of virulence effector proteins that manipulate the host. The pathogen eventually transitions to a necrotrophic phase, where it actively destroys plant tissues and completes its asexual lifestyle by releasing motile zoospores contained within sporangia (Hardham, 2007).

On oil and coconut palms, *P. palmivora* causes bud rot and spear rot. The first symptoms are formation of small, water-soaked lesions in the tender tissue of the leaflets at the base of the spear leaf. Lesions extend to developing leaflets in the heart tissue of the palm. As the lesions dry out, the middle lamella falls out, leaving a shot-hole appearance on the middle of the leaflet and destruction of the interveinal tissues, or bite-like symptoms if the lesions form at the edge of the leaflet. Sequential infections cause more and larger lesions on leaflets near the heart of the palm. In advance stages, the outer part of the spear leaf appears dry, while the central meristem tissues are destroyed. The bud putrefies due to the subsequent invasion by saprophytic microbes and insects. Because palms rely on their hearts to grow, infection of the meristem and the bud leads to the death of the tree (Torres et al., 2016).

On cacao, *P. palmivora* attacks the whole plant leading to various problems including pod rot, bark or stem and cushion canker, cherelle wilt, and chupon blight. Symptoms are spots on fruit, black pod rot, infection of beans, stem canker, and root rot. A small brownish spot appears at the point of infection at the stem- or blossom-ends of fruits. Infection spreads rapidly across the outer surface, covering the entire pod in a few days. Pod infection may also develop from the stalk via an infected flower cushion. Infected areas turn from brown to black and, if conditions are favorable, clusters of white sporangia appear on outer surfaces of the pod. As visible pod symptoms progress, the pathogen moves deeper

into the pod, infecting and destroying the beans. Infected beans quickly deteriorate and rot, rendering the pod valueless. The pods then dry up and mummify on the tree, becoming a major source of inoculum to nearby pods, leaves, and stems. Cankers can form under the bark of infected stems and branches. Stem cankers are characterized by oval to round, rusty-brown discoloration of the external bark that looks purple when scraped. There may be a dark spot on the bark that oozes reddish fluid. The canker can continue to expand until it girdles and kills the branch. Dead and dying leaves are sometimes the first indication of branch dieback. The leaves die because the branch they are on is killed; the pathogen does not directly infect the leaves. The symptoms of collar infections are dark brown, irregular, water-soaked lesions with reddish-brown exudate; these lesions are not noticeable unless accompanied by a gummy exudate. Root rot occurs when spores are moved by rain down into the soil (Vanegtern et al., 2015; CABI - CPC, 2022).

Transmission: Inoculum is spread through rain splash, wind, movement of soil, and human activity. Long distance spread is with the movement of infected nursery stock. All spore types are infective: zoospores, sporangiospores, chlamydospores and oospores, that can spread in multiple ways. Zoospores have been collected from runoff water and flooding zones in oil palm affected orchards (Martinez et al., 2010). The transmission of *P. palmivora* on cacao is complex due to the number of tissues affected and numerous infection routes. At the beginning of the season, transmission occurs from primary inoculum present in soil and plant parts, where it survives the dry season. Multiple infection foci appear simultaneously, often in the same spots as the previous year (Marelli et al., 2019). Pod-boring beetles (Coleoptera: Scolytidae and Nitidulidae) preferentially colonize cocoa pod lesions caused by *P. palmivora* in cocoa plantations. Beetles are attracted to disease lesions and rapidly generate and disseminate secondary inoculum in epidemics of pod rot. Beetles captured from naturally infected pod lesions carry viable pathogen propagules on their bodies. Frass residues on the surface of infected, colonized pods are rich in viable pathogen propagules (Konam and Guest, 2004).

Damage Potential: On the most economically important hosts which include cocoa, coconut, pineapple, rubber tree, durian, citrus, papaya and oil palm, disease outbreaks impact the livelihood and nutrition of millions of people globally. Annual losses due to diseases caused by *P. palmivora*, such as oil palm bud rot and cocoa black pod, range from USD $250 million to over USD $1 billion, respectively (Drenth and Guest, 2013; Torres et al., 2016). Budrot disease of palms has been found in 22 countries (Ghose and Dasgupta, 2000) and it is economically important in Colombia, Indonesia, the Philippines, India, West Africa, the Pacific Islands and Jamaica and often causes severe losses due to loss of entire trees. (CABI CPC-2022).

Worldwide Distribution: Asia: *Cambodia, China, India, Indonesia, Iran, Italy, Japan, Jamaica, Korea, Malaysia, Myanmar, Pakistan, Papua New Guinea, Philippines, Taiwan, Thailand, Turkey, Sri Lanka, Viet Nam*, Africa: *Benin, Brunei Darussalam, Cameroon, Canary Islands, Congo, Cote d'Ivoire, Egypt, Gabon, Ghana, Liberia, Malawi, Mauritius, Morocco, Nigeria, Seychelles, Sierra Leone, Tanzania, Uganda, Zimbabwe*. Europe: *Croatia, France, Greece, Netherlands, Norway, Poland, Spain.* Central America: *Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama*. North America: *Bermuda, Cuba, Dominican Republic, Guadeloupe, Mexico, Puerto Rico, Trinidad and Tobago, United States* (Arizona, California, Florida, Hawaii), *Virgin Islands*. South America: *Argentina, Brazil, Colombia,*

Guyana, Peru, Venezuela, Oceana: *Australia, Cook Islands, Fiji, French Polynesia, Micronesia, New Caledonia, New Zealand, Reunion, Samoa, Solomon Island, Tonga, Vanuatu* (Farr and Rossman, 2022).

Official Control: *Phytophthora palmivora* is on the USDA PCIT's harmful organism list for: Chile, Colombia, Ecuador, French Polynesia, Madagascar, Namibia, New Zealand, Nigeria, Paraguay, Qatar, South Africa, Tanzania, United Republic of Uganda, and United Arab Emirates. It is on the EPPO's A1 list for Bahrain and Chile, a quarantine pest in Morocco and a regulated non-quarantine pest in Egypt (USDA PCIT, 2022; EPPO database, 2022).

California Distribution: There are records from Alameda, Los Angeles, Orange, San Luis Obispo, Santa Barbara, Santa Clara, and Solano counties from pear baits and plants, many recently found during nursery cleanliness projects. Recorded associated hosts are *Asplenium bulbiferum*, *Ceanothus* sp., *Choisya ternata*, *Chamaedorea* sp. *Kentia* sp., *Laurus nobilis*, and *Pittosporum undulatum* (CDFA PDR Database, 2022). *Phytophthora palmivora* was detected in Santa Clara County, in a Santa Clara Valley Water District restoration site by the Rizzo lab, UC Davis (Tyler Bourret pers. comm), associated with *Sambucus mexicana* (Blue elderberry) and *Artemisia californica* (California sagebrush). Frankel et al., (2020) report a detection on *Pittosporum crassifolium* 'Nana' on CA nursery stock. And it has been found during a research project on detection methods from two CA nurseries, once on *Punica granatum* var. *nana* (dwarf pomegranate) and once in nursery irrigation water (J. Alexander, UCCE Marin County, pers. comm).

California Interceptions: None

The risk *Phytophthora palmivora* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** This *Phytophthora* species has mostly been associated with more tropical plants and climates, and it has been found in greenhouses. The minimum temperature for growth 9° C, optimum 24–30° C, maximum 33° C. (Abad et al., 2019). Phytophthoras are dependent on water to spread, making their detection more common in areas with more rainfall.

   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 species is large including herbaceous and woody plants, both agronomic and ornamental species.

   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:** This *Phytophthora* species is heterothallic, capable of outcrossing and producing oospores. It also produces asexual sporangia and chlamydospores (Abad et al., 2019). It spreads easily with splashing water and movement of infected plants and soil.

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 pathogen inflicts large economic costs in areas that produce cacao, oil palms and coconut palms. It is a quarantine pest in several countries. It can be vectored by beetles in cacao. It can be moved with water

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

Economic Impact: A, B, C, E, G
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:** In 1993, Bernard and Mitchell reported *P. palmivora* causing a basal canker on red maple (*Acer rubrum*) for the first time in the United States in Florida. However, no reports on the actual impact of this species on hardwood trees have been found to date. It has been found multiple times in California nurseries but has not-demonstrated virulence like *P. ramorum*, with whom it shares the traits of being, airborne, foliar infecting, and having a wide host range. Although it has been detected in association with some native species, it is often found co-infecting with similar pathogens, making it difficult to quantify the damage it is causing.

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

Environmental Impact: A, B

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 *Phytophthora palmivora:* 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.

This pathogen has been known in California since 1947 and has had an unofficial C-rating for many years, meaning little regulatory action has been taken. However, from a comprehensive nursery survey for *Phytophthora* spp. and personal communications with Phytophthora researchers, this is not a species that is commonly found (Rooney-Latham et al., 2019), likely due to environmental limitations.

Evaluation is 'medium'.

Score: -2
-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* ***= 12***

Uncertainty:

In 2021, Scanu et al. described *P. heterospora* sp. nov. as a sister species of *P. palmivora,* associated with stem lesions and root and collar rot on young olive trees in Southern Italy. Based on morphological characters and 99% similarity of the internal transcribed spacer (ITS) sequences, it was initially identified as *P. palmivora*. However, most of the isolates behaved unusually—in addition to producing the typical papillate sporangia of *P. palmivora*, the isolates also produced conidia-like sporangia that exclusively germinated directly via germ tubes. Similar isolates had been reported in various countries on several hosts. It seems *P. heterospora* could have been mistaken for *P. palmivora* many times. All the pre-molecular host-location data for *P. palmivora* ought to be validated and confirmed as either *P. palmivora* or *P. heterospora* (T. Bourett, UC Davis, pers.com.).

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Phytophthora palmivora* is B.

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Responsible Party:

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***Comment Period: 07/18/2022 through 09/01/2022**

***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: B