CAPS Datasheets provide pest-specific information to support planning and completing early detection surveys.

Caribbean palm lethal decline (CPLD) phytoplasmas

Scientific Name

'*Candidatus* Phytoplasma palmae' and related strains

Common Names

palm lethal yellowing, palm lethal decline, Caribbean palm lethal decline, *Carludovica palmata* yellows, coconut lethal decline, coconut lethal yellowing, coyol palm decline, date palm lethal decline, lethal bronzing, lethal bronzing, lethal yellowing, Texas Phoenix palm decline, *Washingtonia* palm decline, Yucatan coconut lethal yellows

Figure 1: Leaf yellowing on *Cocos nucifera* (Photo courtesy of Dr. Nigel Harrison, University of Florida, Dr. Monica Elliott, University of Florida, Institute of Food and Agricultural Sciences, and Ian Maguire, University of Florida, Institute of Food and Agricultural Sciences)

Type of Pest

Phytoplasma

Taxonomic Position

Class: Mollicutes
Order: Acholeplasmatales
Family: Acholeplasmataceae

Notes on taxonomy and nomenclature: Current taxonomic status of this group is based on consensus of 16S rRNA, 16S-23S intergenic spacer region (IGS), *secA* gene, and *groEL* gene sequence data. Palm lethal decline phytoplasmas belong to the 16SrIV group, and there are, historically, five known strains (A,B,C,D,E) and one putative subgroup (F) (Soto et al., 2021). However, subgroup B was recently found to be identical to subgroup D (Soto et al., 2021). Information about these phytoplasma strains is constantly changing as it becomes available.

Pest Recognition

Disease recognition is by the sequential and progressive development of symptoms that can vary by species and cultivar (Bahder and Helmick, 2018). For mature, fruit-bearing palms infected by these phytoplasmas, the earliest visible symptom is often premature fruit-drop with most of the fruit dropping within a few days (Harrison and Elliott, 2016). Fruit shed from coconut often develop a blackened or water-soaked appearance at the calyx end (Bahder and Helmick, 2018). Newly emergent inflorescences become necrotic (Harrison and Elliott, 2016).

Foliage generally becomes discolored (Fig. 1,2,3,4) after the fruit and flowers show symptoms; however, if fruit is not present, lower leaf discoloration may be the first symptom. Discoloration begins on the lowermost (oldest) leaves and progresses to the younger leaves in the upper part of the crown (Fig. 2, 3, 4) (Harrison and Elliott, 2016). Discolored leaves

Figure 2: Lethal bronzing on *P. canariensis* (left). Lethal bronzing on a *P. sylvestris* (right). (Photos courtesy of Dr. Raghuwinder Singh, Department of Plant Pathology and Crop Physiology, Louisiana State University Agricultural Center)

often remain turgid for some time before turning brown, drying, and hanging from the stem for several weeks before falling to the ground (Bahder and Helmick, 2018). Generally, as disease progresses, the apical meristem dies, the crown withers and falls, and the bare trunk is left standing. This is known as the 'telephone pole' stage (Nampoothiri et al., 2018). For *Trachycarpus fortunei* (Chinese windmill palms), the crown remains intact, even after palm death (Singh, 2021). Most affected palms die within three to six months after the onset of symptoms (McCoy et al., 1983; Mpunami et al., 1999).

Easily Mistaken Species

On their own, visible symptoms are insufficient to diagnose phytoplasma infection. Lethal yellowing disease symptoms can be confused with those caused by *Ganoderma* butt rot, boron deficiency, and potassium deficiency (El Bouhssini and Faleiro, 2018). *Ganoderma* butt rot, caused by the fungus *G. zonatum*, is a basal stem rot that leads to canopy wilting, premature death of lower leaves, and spear leaf (Elliott and Broschat, 2000). Potassium deficiency causes discoloration and premature death of the lowest leaves, which progresses upward. Potassium deficiency can be fatal (HGIC, 2017). Boron deficient palms tend to drop fruit prematurely while inflorescences may be necrotic near the tips (Broschat, 2005).

Biology and Ecology

Phytoplasmas evolved from gram-positive bacteria, lack a cell wall, and cannot easily be cultured (Adkins et al., 2020; Hogenhout et al., 2008b). These obligate, intracellular parasites of plants and insects can only be identified and classified using molecular sequence data (Harrison et al., 2002a; Hogenhout et al., 2008b). Lethal yellowing phytoplasmas tend to accumulate in the lower part of the stem in palm hosts but may be present throughout the plant. Other locations of accumulation include the stem, young leaves, inflorescences, stem apex, and root apex (Bahder et al., 2020; Oropeza et al., 2011).

Phytoplasmas are transmitted between plants by phloem-feeding insect vectors (Dabek, 1975), which can acquire a phytoplasma from a host plant in a few minutes (Wakil et al., 2015). These vectors are often in the Order Hemiptera and can be persistent in transmitting the phytoplasma (Hogenhout et al., 2008a; Weintraub and Beanland, 2006). The time between infection and onset of symptoms, known as the incubation period, is estimated at 112 to 262 days for lethal yellowing diseases in palms (Dabek, 1975; Weintraub and Beanland, 2006).

Figure 3: Left and middle: Lethal bronzing on *T. fortunei* (Chinese windmill palm). Right: Lethal bronzing on *P. dactylifera* (date palm). (Photos courtesy of Dr. Raghuwinder Singh, Department of Plant Pathology and Crop Physiology, Louisiana State University Agricultural Center)

Known Hosts

These phytoplasmas infect numerous palm trees in the Arecaceae family, particularly *Adonidia merrilli, Phoenix canariensis*, *P. dactylifera, P. sylvestris, Pritclzarida* sp., *Sabal palmetto,* and *T. fortunei* (Harrison and Elliott, 2016; Harrison and Oropeza, 2008; Singh, 2021). There are also a few non-palm hosts in various families.

The host list below includes cultivated and wild plants that 1) are infected or infested by the pest under natural conditions, 2) are frequently described as major, primary, or preferred hosts, and 3) Feed and damage per the direct evidence in the literature. Plants highlighted in bold are commercially produced and have pest that causes economically significant damage.

Preferred hosts

Acrocomia aculeata (syn. *A. mexicana*) (coyol palm)*, ***Adonidia merrillii* (Christmas palm, Manila palm)***, *Aiphanes lindeniana* (ruffle palm), *Allagoptera arenaria* (Kuntze seashore palm)*, *Arenga engleri* (dwarf sugar palm)*, *Attalea butyracea* (kuakish)*, *Bismarckia nobilis* (Bismarck palm)*, *Borassus flabellifer* (palmyra palm, toddy palm)*, *Brahea brandegeei* (San Jose hesper palm)*, *Butia capitata* (jelly palm, pindo palm)*, *Butiagrus nabonnandii* (mule tree palm)*, *Carpentaria acuminata* (Carpentaria palm)*, *Caryota mitis* (Burmese fishtail palm)*, *C. rumphiana* (Albert palm, fishtail palm)*, *Chelyocarpus chuco* (round leaf palm)*, *Coccothrinax readii* (Mexican silver palm), ***Cocos nucifera* (coconut palm)***, *Copernicia alba* (caranday palm), *Corypha taliera* (Dhaka palm), *C. utan* (buri palm, gebang palm), *Crysophila warsecewiczii* (rootspine palm), *Cyphophoenix nucele* (Lifou palm)*, *Dictyosperma album* (common princess palm, hurricane palm)*, *Dypsis cabadae* (cabada palm)*, *D. decaryi* (triangle palm)*, *Gaussia attenuata* (Puerto Rican gaussia palm)*, *Howea belmoreana* (Belmore sentry palm)*, *H. forsteriana* (Forster sentry palm, kentia palm)*, *Hyophorbe verschaffeltii* (spindle palm)*, *Latania lontaroides* (red latan palm)*, ***Livistona chinensis* (Chinese fan palm, Chinese fountain palm)***, *L. rotundifolia* (footstool palm)*, *Nannorrhops ritchieana* (mazari palm), *Pandanus utilis* (common screwpine)*, ***Phoenix canariensis* (Canary Island date palm)***, ***P. dactylifera* (date palm)***, *P. reclinata* (Senegal date palm)*, *P. roebelenii* (pygmy date palm)*, *P. rupicola* (cliff date palm)*, ***P. sylvestris* (date sugar palm, silver date palm)***, ***Pritchardia maideniana* (syn. *P. affinis*) (Kona palm)***, ***P. pacifica* (Fiji fan palm)***, ***P. remota* (loulu)* <<endangered>>**, ***P. thurstonii* (Thurston's palm)***, ***Pseudophoenix sargentii* (buccaneer palm)***, *Ravenea hildebrandtii* (dwarf majesty palm)*, *Roystonea regia* (Cuban royal palm, Florida royal palm), *Sabal mexicana* (Mexican palmetto, Rio Grande palmetto)*, *S. palmetto* (blue palmetto, cabbage palm)*, *Syagrus romanzoffiana* (giriba palm, queen palm)*, *S. schizophylla* (arikury palm)*, *Thrinax radiata* (Florida thatch palm)*, *Trachycarpus fortunei* (Chinese windmill palm)*, *Veitchia arecina* (syn. *V. montgomeryana*) (Montgomery palm)*, *V. macdanielsii* (sunshine palm), *Washingtonia robusta* (Mexican fan palm)*, *Wodyetia bifurcata* (foxtail palm)* (Avina-Padilla et al., 2011; Bahder et al., 2017; Bahder et al., 2018; Bahder and Helmick, 2018; Bahder et al., 2019b; Bahder et al., 2020; Broschat et al., 2002; Brown and McLaughlin, 2011; Caldwell, 2004; Cordova Lara et al., 2017; Dey et al., 2018; Ferguson and Singh, 2018; Ferguson et al., 2020; Harrison et al., 1999; Harrison et al., 2002a; Harrison et al., 2008; Harrison and Oropeza, 2008; Harrison and Elliott, 2008; Harrison and Elliott, 2016; Jeyaprakash et al., 2011; Cordova Lara et al., 2017; Martinez et al., 2008; Myrie et al., 2014; Narvaez et al., 2006; Narvaez et al., 2016; Narváez et al., 2018; Palma-Cancino et al., 2020; Poghosyan et al., 2019; Ramos Hernández et al., 2020; Roca et al., 2006; Rodrigues et al., 2010; Singh and Ferguson, 2017; Thomas, 1979; Vázquez-Euán et al., 2011)

Non-palm hosts

Carludovica palmata (Panama hat palm)*, *Cyanthillium cinereum* (syn. *Vernonia cinerea*) (little ironweed)*, *Emilia fosbergii* (Florida tasselflower)*, *Macroptilium lathyroides* (phasemy-bean)*, *Stachytarpheta jamaicensis* (blue snakeweed)*, *Synedrella nodiflora* (cinderella-weed, synedrella)* (Brown and McLaughlin, 2011; Brown et al., 2008a; Brown et al., 2008b; Cordova et al., 2000).

* Hosts with U.S. distribution

Pest Importance

Palms are horticulturally valuable ornamentals and important assets for the tourism industry (Broschat et al., 2014). In 2019, the top five palm-growing states were Florida ($300 million), California ($61 million), Hawaii ($24 million), Texas ($9 million), and Washington ($4 million) (NASS, 2021b). Palms are also valuable for agriculture. Date production in the United States occurs in California and Arizona, and coconuts are produced in Puerto Rico and other U.S. territories (NASS, 2021b). In 2019, date production in the United States was valued at $220 million (NASS, 2021a).

Figure 4: Top left: *P. sylvestris* with initial symptoms of lethal yellowing. Top right: *P. dactylifera* with early fruit fall. Bottom left: *P. sylvestris* with discolored foliage. Bottom right: *S. palmetto* with dead leaves and spear leaf, young leaves are still green (Photos courtesy of Dr. Nigel Harrison, University of Florida, Dr. Monica Elliott, University of Florida, Institute of Food and Agricultural Sciences, B. Dick and Ian Maguire, University of Florida, Institute of Food and Agricultural Sciences)

'*Candidatus* Phytoplasma palmae' and its related strains are considered one of the most important global threats to coconut production in the Caribbean basin (Bahder, 2021; Eden-Green, 1997). Since palm lethal yellowing was discovered in Key West, this disease has crept northward, killing hundreds of thousands of palm trees and endangering virtually all tall coconut palms in Florida (Broschat and Crane, 2005). In the 1950's, 15,000 palms died in Key West, dramatically changing the landscape of the city (Martinez and Roberts, 1967). More recently, the once prevalent 'Jamaica tall' coconut palm in Florida has been decimated due to palm lethal yellowing (Harrison et al., 2002a). Similarly, this disease is responsible for the death of most of the 'Atlantic tall' coconut palm in the Yucatan region of Mexico (Narvaez et al., 2006). Losses due to these phytoplasmas for Florida's nursery and landscaping industry may exceed tens of millions of dollars (Bahder et al., 2019b).

'*Candidatus* Phytoplasma palmae' and its related strains are listed as harmful organisms in Albania, Brazil, Chile, Colombia, Costa Rica, Egypt, European Union, Guatemala, Holy See (Vatican City State), India, Indonesia, Israel, Korea, Republic of, Mexico, Monaco, Morocco, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, San Marino, Serbia, Turkey, United Arab Emirates, and the United Kingdom (USDA PCIT, 2021). There may be trade implications in these countries if these phytoplasmas spread farther in the United States.

Known Vectors (or associated insects)

The only confirmed vector of '*Candidatus* Phytoplasma palmae' is the planthopper *Haplaxius* (*Myndus*) *crudus* (Hemiptera: Cixiidae, Fig. 5) (Dzido et al., 2020; Howard et al., 1983). *Haplaxius crudus* is present in the United States, namely, Florida, Louisiana, Mississippi, Puerto Rico, and Texas (Hill et al., 2018; Humphries et al., 2021; Meyerdirk and Hart, 1982; Mou et al., 2020a; Segarra-Carmona et al., 2013). Harrison et al., (2008) describes *H. crudus* as "not cold hardy" but adults have been found throughout the winter in Gainesville, Florida (Halbert et al., 2014). One study suggests that during cooler temperatures, *H. crudus* prefers short palms but will move to tall palms in warmer temperatures (Mou et al., 2020b).

Figure 5: Male (left) and Female (right) *Haplaxius* (*Myndus*) *crudus*, the vector of '*Ca*. Phytoplasma palmae' (Photos courtesy of Dr. Nigel Harrison, University of Florida)

Known Distribution

Africa: Benin, Cameroon, Côte d'Ivoire, Ghana, Mozambique, Nigeria, Tanzania Togo; **North America:** Antigua and Barbuda, Belize, Cayman Islands, Cuba, Dominican Republic, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Mexico, Netherlands Antilles, Saint Kitts and Nevis, United States; **Oceana:** Papua New Guinea, Solomon Islands (Adkins et al., 2020; Bahder et al., 2017; Bahder et al., 2019b; CABI, 2021; Córdova et al., 2014; Cordova Lara et al., 2017; Davis et al., 2015; Dey et al., 2018; Ferguson and Singh, 2018; Gurr et al., 2016; Harrison et al., 2002a; Harrison et al., 2002b; Harrison et al., 2008; Kelly et al., 2011; Llauger et al., 2002; Mejía et al., 2004; Myrie et al., 2012; Myrie et al., 2014; Palma-Cancino et al., 2020; Ramos Hernández et al., 2020; Roca et al., 2006; Rodrigues et al., 2010; Singh and Ferguson, 2017; Soto et al., 2021; Vázquez-Euán et al., 2011).

Status of infestation in the United States (May 2022)

'*Candidatus* Phytoplasma palmae' subgroups A and D are known to be present in the United States (Soto et al., 2021), specifically in Florida, Louisiana, Puerto Rico, and Texas (Bahder et al., 2019b; Dey et al., 2018, Harrison et al., 2002b; Rodrigues et al., 2010; Singh and Ferguson, 2017). The presence of lethal yellowing of palms (Subgroup A) in Florida is suspected as far back as the 1930's in Key West (Martinez and Roberts, 1967). Palm lethal decline (Subgroup D) is believed to have been introduced to Florida in the early 2000's (Elliott, 2009) and is present in at least 31 counties (Bahder et al., 2019a). The first recognition of palm lethal decline (Subgroup D) in Texas was in Brownsville in the mid 1970's (McCoy et al., 1980). In Texas, Subgroup D is still limited to the southern part of the state (Ong and McBride, 2009). Subgroup D was first identified in Louisiana in 2013 (Ferguson et al., 2020; Singh, 2014), and is now present in at least five parishes (Ferguson et al., 2020).

Pathway

Long-distance spread occurs when infected host plant material or infective insects are transported to a new area (Nampoothiri et al., 2018; Narvaez et al., 2006). Infected vectors are thought to have brought the phytoplasma to Jamaica in the 1870's by hitchhiking on host plant material that was transported there (Nampoothiri et al., 2018; Ogle and Harries, 2005). Hitchhiking vectors are also implicated in the introduction of lethal bronzing and lethal yellowing to Florida (Elliott, 2009; Humphries et al., 2021). Hurricane winds may also carry insect vectors to new locations (Dollet et al., 2009; Nampoothiri et al., 2018). Seed transmission is not known to occur, but there is some experimental evidence that it may be possible (Oropeza et al., 2011; Oropeza et al., 2017).

Use the PPQ Commodity Import and Export manuals listed below to determine 1) if host plants or material are allowed to enter the United States from countries where the organism is present and 2) what phytosanitary measures (e.g., inspections, phytosanitary certificates, post entry quarantines, mandatory treatments) are in use. These manuals are updated regularly.

Fruits and Vegetables Import Requirements (FAVIR) Online Database: The FAVIR database lists all importation requirements for fruits and vegetables. To search by commodity, select 'Approved Name' at the top left of the page. Select the commodity from the dropdown menu and then click 'Search'. Click on the 'Commodity Summary' tab for details.
https://epermits.aphis.usda.gov/manual/index.cfm?action=pubHome

Plants for Planting Manual: This manual is a resource for regulating imported plants or plant parts for propagation including buds, bulbs, corms, cuttings, layers, pollen, scions, seeds, tissue, tubers, and like structures.
https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/plants_for_planting.pdf

Cut Flowers and Greenery Import Manual: This manual is a resource for regulating imported fresh, cut plants used for decoration and for protecting plants from extinction due to trade.
https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/cut_flower_imports.pdf

Miscellaneous and Processed Products Import Manual: This manual is a resource for regulating imported processed plant and non-plant that may introduce exotic pests.
https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/miscellaneous.pdf

Treatment Manual: This manual provides information about treatments applied to imported and domestic commodities to limit the movement of agricultural pests into or within the United States.
https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf

Potential Distribution within the United States

Coconut palms grow in Florida, Georgia, Hawaii, North Carolina, South Carolina, Puerto Rico, and the Virgin Islands (USDA NRCS, 2021). Date palms (*P. dactylifera*) are commercially grown in California and Arizona (NASS, 2021b). In addition, many species of ornamental palms have also been introduced into the United States, including *P. canariensis*, *P. roebelenii*, and *W. bifurcata* (Broschat et al., 2014). Palms native to the United Sates include *R. regia*, *S. palmetto*, and *S. Mexicana* (Bahder et al., 2019b; Broschat et al., 2014; USDA NRCS, 2021). A comparison of the Plant Hardiness Zones (Takeuchi et al., 2018) where palms are found and the range of conditions known to be favorable for *H. crudus*, the only confirmed vector, indicates that this pest may establish in Zones 9-13.

Survey and Key Diagnostics

Approved Methods for Pest Surveillance*: For the current approved methods and guidance for survey and identification, see Approved Methods for Pest Surveillance (AMPS) pest page on the CAPS Resource and Collaboration website, at https://caps.ceris.purdue.edu/approved-methods.

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USDA-APHIS-PPQ-ST staff developed this datasheet. Cite this document as:

PPQ. 2022. Cooperative Agricultural Pest Survey (CAPS) Pest Datasheet for *'Candidatus* Phytoplasma palmae' and related strains (Acholeplasmataceae). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ), Raleigh, NC.

Draft Log

June 2013: Original datasheet developed and posted to CAPS website.
June 2014: Revised **Known Distribution** and **Known Hosts** sections.
May 2018: Revised **Known Distribution** and **Known Hosts** sections.
May 2022: Revised the entire datasheet to include current information, and reformatted.

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