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

‘*Candidatus* Phytoplasma australiense’

‘*Candidatus* Phytoplasma australiense’ Davis et al.,1997

Synonym(s):
None

Common Name

Disease: Australian grapevine yellows, Australian lucerne yellows, *Coprosma* lethal decline, *Cordyline* sudden decline, Papaya dieback, *Phormium* yellow leaf, Pumpkin yellow leaf curl, Strawberry green petal, and Strawberry lethal yellows

Pathogen: Australian grapevine yellows phytoplasma, *Phormium* yellow leaf phytoplasma, strawberry green petal phytoplasma, and strawberry lethal yellows phytoplasma

Type of Pest

Phytoplasma

Taxonomic Position

Class: Mollicutes, **Order:** Acholeplasmatales, **Family:** Acholeplasmataceae

Notes on taxonomy and nomenclature:

Since phytoplasmas are obligate parasites that cannot be cultured in a lab outside of their host plants or insect vectors, the only way to classify them is by analyzing their genetic material, specifically comparing the similarities in their gene and genome sequences (Wei et al., 2022). In 2022, revised guidelines of the ‘*Candidatus* Phytoplasma’ species description have been introduced by the International Committee on Systematic Bacteriology (ICSB) Subcommittee on the Taxonomy of Mollicutes (Bertaccini et al., 2022).

In general, a strain can be described as a novel ‘*Ca*. Phytoplasma’ species if its full length or nearly full length (>1500 bp) 16S rRNA gene sequence shares <98.65% identity or its whole genome shares an ANI score <95-96% to that of any previously described ‘*Ca*. Phytoplasma’ species. Strains in which even minimal differences in the 16S rRNA gene sequence from the reference strain are detected are referred as ‘related’ to the *Candidatus* species (Wei et al., 2022).

Although fine-scale molecular classification has been useful for taxonomy and nomenclature, this classification is not predictive of host species or symptoms (Seemüller et al., 1998; Streten et al., 2005b).

‘*Candidatus* Phytoplasma australiense’ belongs to the 16SrXII (Stolbur) group of phytoplasmas, subgroup B (Davis et al., 1998). Within the 16SrXII-B subgroup, a few different lineages have been identified based on sequence comparisons of the *tuf* and *rp* genes, with each lineage originating from either Australia or New Zealand (Andersen et al., 2006; Streten et al., 2005b; Tran-Nguyen et al., 2008). It is unclear at this time if there are variations in host range or symptoms across any of the lineages (Dermastia et al., 2017; Streten et al., 2005b).

Pest Recognition

This section describes characteristics of the organism and symptoms that will help surveyors recognize possible infestations/infections in the field, select survey sites, and collect symptomatic material. For morphological descriptions, see the Identification/Diagnostic resources on the AMPS pest page on the CAPS Resource and Collaboration website.

Pest Description

'*Ca.* P. australiense', like other phytoplasmas, resides in the phloem tissue of infected plants and the gut and salivary glands of insect vectors (Hogenhout et al., 2008). It cannot be cultured *in vitro*, nor can it be distinguished from other phytoplasmas without using molecular approaches, as distantly-related phytoplasmas often induce similar symptoms (Davis et al., 1998). Expression of disease in plants infected with '*Ca*. P. australiense' may be followed by remission in some individuals and recurrence of disease in others, as well as the occurrence of disease in previously unaffected plants (Magarey et al., 2006). Infected plants may also be symptomless (Liefting et al., 2011a; Magarey et al., 2006).

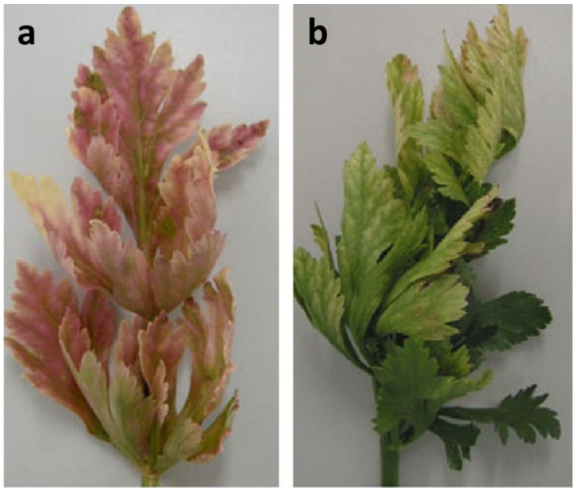

Figure 1. Symptoms associated with '*Ca.* P. australiense' in celery: a) pink discoloration and b) yellowing of leaves (Courtesy of Liefting et al., 2011a. CC-BY 3.0, cropped for space)

Symptoms

Apium graveolens (celery): Symptoms include unusual pink and yellow foliage (Fig. 1 a, b) and leaf deformation (Liefting et al., 2011a; Liefting et al., 2011b).

Carica papaya (papaya): Affected plants show a bunched appearance of inner crown leaves, with one or more leaves shriveling and dying (Gibb et al., 1996; White et al., 1998). The larger crown leaves rapidly turn yellow and then necrotic (Fig. 2 a, b) (Gibb et al., 1996; White et al., 1998). The entire crown dies within 1 to 4 weeks, and the stem gradually dies back from the top (Fig. 2 c) (Gibb et al., 1996; White et al., 1998). Affected plants also develop necrosis of the phloem and a reduction in latex flow (Gibb et al., 1996; White et al., 1998). There may be abnormal ripening or premature fruit drop (Gibb et al., 1996; White et al., 1998). Young plants succumb to dieback, but if the affected stem is cut, older plants may recover to produce healthy side shoots from lateral buds (Gibb et al., 1996; White et al., 1998).

Figure 2. Symptoms associated with '*Ca.* P. australiense' in papaya: a) early symptoms of leaf yellowing and bunching in the crown leaves; b) death of new crown leaves; c) advanced dieback (Courtesy of Cooke et al., 2010. CC-BY 3.0, cropped for space)

Cucurbita maxima (pumpkin) and *C. moschata* (butternut squash): Leaves become yellow and curled, and plants exhibit stunted growth (Streten et al., 2005a).

Fragaria x *ananassa* (strawberry): Infected plants may become flatter to the ground than adjacent healthy plants and their foliage growth more open. Older leaves become purple-bronze in color, particularly toward the margin (Fig. 3 a). Young leaves are smaller than normal, with shortened petioles and a conspicuous yellowing initially occurring around the leaf margin, but later covering much of the leaf. Leaves on runners are small, curled, and twisted, light yellow in color, and form rosettes (Fig. 3 b). Flower and fruit production may be inhibited although not misshapen. The disease may be lethal, although sometimes plants remain alive but have poor growth (Andersen et al., 1998; Queensland Government, 2022; Streten et al., 2005d).

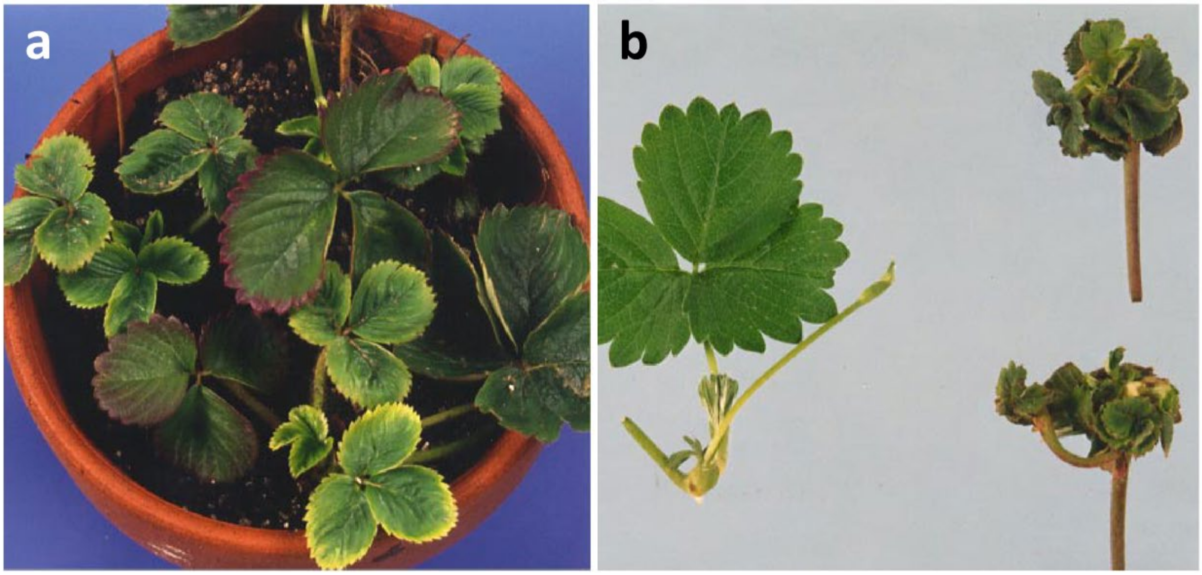

Figure 3. Symptoms associated with ‘*Ca.* P. australiense’ in strawberry: a) older leaves display purple bronzing, and younger leaves show yellowing on the margins; b) leaves are twisted and curled into rosettes on right, and healthy sample shown on left (Courtesy of Andersen et al., 1998. CC-BY 3.0, cropped for space).

Liquidambar styraciflua (sweetgum): Plants show patchy yellowing of the crown and dieback as well as fewer fruits and shoots (Habili et al., 2007).

Medicago polymorpha (burclover) and *Medicago sativa* (alfalfa, lucerne): In burclover, leaves are smaller and red or yellow (Streten et al., 2005c). In alfalfa, symptoms include yellowing and witches’ broom (Getachew et al., 2007).

Paulownia tomentosa (empress tree): Plants show interveinal yellowing on leaves, reduced internodes, reduced leaf size, and stunting of growth (Bayliss et al., 2005).

Phormium cookianum (mountain flax), *P. tenax* (New Zealand flax): Symptoms include abnormal yellowing of leaves, stunted growth, increased root death, premature flowering, and rhizome rotting (Liefting et al., 1996).

Rubus ursinus (boysenberry): Symptoms become obvious close to flowering when lateral branches become stunted, and young leaves are yellow and smaller than normal (Fig. 4 a). Older leaves become purple-bronze, particularly towards the margin (Fig. 6 b) (Liefting et al., 2011b). Fruit develop but remain small (Liefting et al., 2011a).

Figure 4. Symptoms associated with '*Ca.* P. australiense' in boysenberry: a) stunting and yellowing of leaves and b) older leaves turn purple-bronze (Courtesy of Liefting et al., 2011a. CC-BY 3.0, cropped for space).

<u>*Solanum tuberosum* (potato)</u>: Symptoms include upward rolling and purpling of leaves (Fig. 5 a, b). The symptoms may appear similar to those in zebra chip disorder, to which the psyllid-vectored bacterium '*Ca.* Liberibacter solanacearum' is linked in New Zealand and the United States (Liefting et al., 2009; Nischwitz et al., 2015). Zebra chip disorder causes necrotic flecking and brown discoloration of the tubers in a zebra stripe pattern, rendering affected tubers unmarketable (Prager et al., 2022). Although there is limited information about tuber symptoms caused by '*Ca.* P. australiense' infection, Liefting et al. (2011a) reports that potato tubers infected with '*Ca.* P. australiense' have failed quality control checks in processing facilities, suggesting that symptoms include similar tuber discoloration.

Figure 5. Symptoms associated with '*Ca.* P. australiense' in potato: a) upward rolling, purpling of leaves and b) stunting (Courtesy of Lia W. Liefting, cropped for space).

Trifolium spp. (clover): Affected plants show diminished leaf size, pallor, reddening or yellowing of leaves (Fig. 6), wrinkled, deformed leaves, shoot proliferation, clumping of the plant, and stunting (Saqib et al., 2006; Streten et al., 2005c).

Figure 6. Diminished leaf size, leaf yellowing, and stunting associated with '*Ca.* P. australiense' in clover on bottom right with three larger, asymptomatic plants (Saqib et al., 2006. CC-BY 3.0, cropped for space).

Vitis vinifera (grape): Symptoms begin from flowering onwards. Some varieties such as the white cultivars Riesling and Chardonnay and the red variety Sangiovese, are more severely affected than others (Magarey et al., 2006; Padovan et al., 1995). Diagnostically, diseased leaves curl downward and exhibit irregular, blotchy yellowing (chlorosis), sometimes along main veins (Fig. 7 a), although chlorosis is often more obvious on leaves of Riesling than of Chardonnay (Magarey et al., 2006). In red varieties, affected leaves redden within a distinctly demarked border along a vein (often a primary or secondary vein) (Fig. 7 b) (Magarey et al., 2006). Chlorotic patches on leaves often become necrotic, especially in hot weather. In some seasons, leaves on affected shoots of some white varieties e.g., Chardonnay, and of most red varieties, roll tightly downward as the season progresses (Fig. 7 a, c) (Constable et al., 2011; Magarey et al., 2006). Affected leaves often overlie each other like scales on a fish, and they fall prematurely. Diseased shoots are stunted because shoot tips (apices) cease activity and die, frequently breaking off at the nodes. Affected shoots fail to lignify and depending on the variety of vine, especially Riesling, can take on a bluish hue, become rubbery (Fig. 7 f), and die (Fig. 7 g). Likewise, on varieties such as Riesling, in cool springs small black pustule-like deformations develop on the lower internodes of affected shoots (Magarey et al., 2006). Flowers and young berries shrivel and often die (Fig. 7 d, e) so that by harvest, affected shoots are barren (Magarey et al., 2006). It is thought by some that affected shoots display a zig-zag growth habit, but this is a symptom of other conditions not consistent with Australian grapevine yellows (Magarey et al., 2006). Typically, only a single shoot or several adjacent shoots on the same arm show symptoms (Bonfiglioli et al., 1995; Constable et al., 2011; Magarey et al., 2006).

Rarely do affected vines die, but depending on the season, the yield from susceptible varieties may be significantly reduced (Constable et al., 2011; Magarey et al., 2006). Infected grapevines rarely show symptoms every season (Constable et al., 2004), and an arm of a vine affected last season may exhibit remission and be symptomless in the next, although spurs bearing an affected shoot last season may die overwinter, leaving a gap in the canopy in the second season (Magarey et al., 2006). Another distinguishing symptom of Australian grapevine yellows is the evidence of natural heat therapy of shoots when otherwise severely diseased shoots exhibit regrowth of shoot apices following several days of high temperatures (above 100°F) (Magarey et al., 2006).

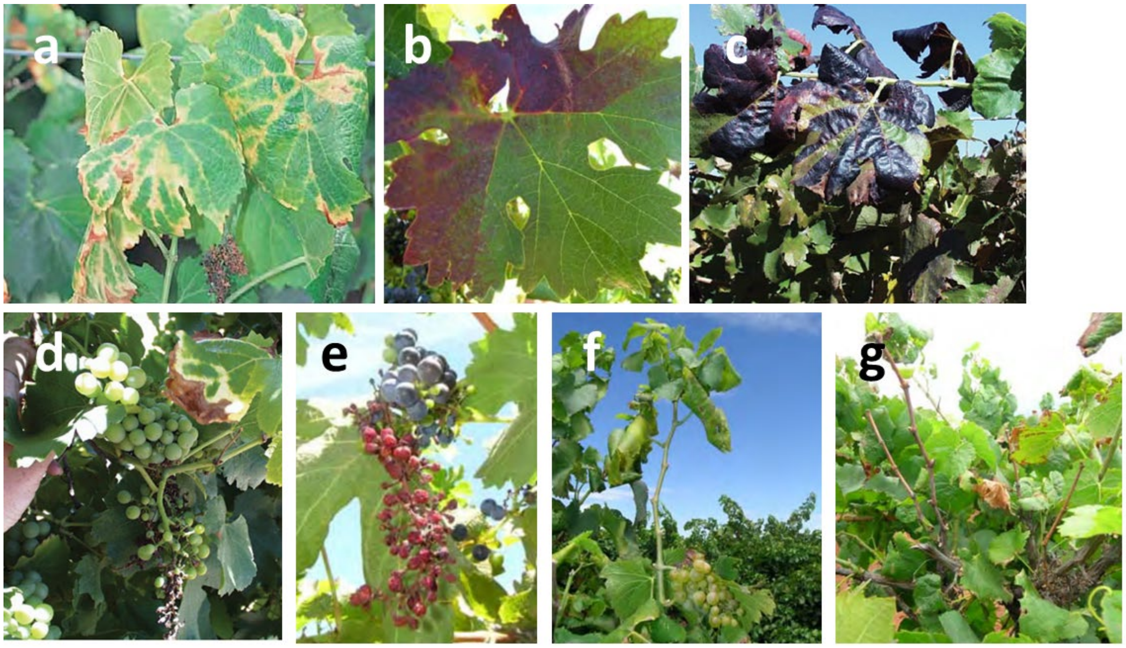

Figure 7. Symptoms associated with '*Ca.* P. australiense' in grape: a) irregular yellowing and downward leaf curling in white grape variety; b) irregular reddening and c) downward leaf curling in red grape variety; berry shriveling in d) white variety and e) red variety; f) shoot remains green and does not lignify but becomes rubbery; and g) shoot die back from tip, often breaking at the nodes (Courtesy of Constable et al., 2011 (c, d) and Magarey et al., 2006 (a, b, e, f, g). CC-BY 3.0, cropped for space).

Easily Mistaken Species

Other phytoplasmas cause similar symptoms and they can only be distinguished by molecular methods.

Similar plant symptoms are associated with:

- '*Ca.* Phytoplasma solani' (16SrXII-A). Found in Asia, Europe, the Middle East, and Chile (EFSA, 2014; Gajardo et al., 2009)
- '*Ca.* Phytoplasma australasiae'. Found in Australia, Asia, and North Africa (Bertaccini et al., 2022; Singh et al., 2012; White et al., 1998)

- Buckland Valley grapevine yellows phytoplasma (16SrXXIII-A). Found in Australia (Wei et al., 2022).

None of the above pathogens are known to be present in the United States, although '*Ca*. P. solani' was found in Canada in 2006 and then eradicated (Dermastia et al., 2017).

Within the United States, North American grapevine yellows (NAGY) disease may be mistaken for '*Ca.* P. australiense' (Dermastia et al., 2017). This disease is associated with the Virginia grapevine yellows strain and multiple '*Ca.* P. pruni'-related strains (Bisztray et al., 2012; Davis et al., 2015). Symptoms of NAGY are very similar to those caused by '*Ca.* P. australiense' (Constable et al., 2004; Davis et al., 2015). North American grapevine yellows occurs in Arkansas, Kansas, Maryland, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, and Virginia (Costanzo, 2024; Davis et al., 2019; Dermastia et al., 2017).

Biology and Ecology

Like all other phytoplasmas, the biology of '*Ca.* P. australiense' remains only partially understood. Phytoplasmas are characterized by a single membrane, lack of a rigid cell wall, and are ~500 nm in diameter (Hogenhout et al., 2008). They are obligate intracellular parasites of plants and insects, residing in the phloem tissue of infected plants and the gut and salivary glands of phloem-feeding insect vectors (Hogenhout et al., 2008).

Phytoplasmas are acquired by leafhoppers, planthoppers, and psyllids when they feed on the phloem of infected plants. The ingested phytoplasma cells cross the insect's gut into the hemocoel, where they multiply. The phytoplasma then moves into the salivary gland and multiplies further. Once the salivary glands are infected, which may take 2-6 weeks, the vector can then transmit the phytoplasma to a new host during feeding. The vector remains infective for life. Once the plant host is infected, there is a latent period before symptoms are expressed, while the phytoplasma multiplies in the phloem. The phytoplasma can spread throughout the plant, including the roots (Streten et al., 2006).

Some evidence suggests that this phytoplasma has an extended (over 8 months) incubation period in grapevine before symptoms occur (Constable et al., 2004; Dermastia et al., 2017; Magarey et al., 2006). Within individual grapevines, symptoms can recur or remit from season to season (Magarey et al., 2006). This is thought to be because infected shoots are unable to lignify (harden off) and they typically die back during the cold season (Magarey et al., 2006). Additionally, severely diseased shoots have been observed to grow back normally after 1-2 days of daily maximum temperatures greater than 100°F, conditions that are likely to kill or greatly reduce the titer of the pathogen (Magarey et al., 2006).

Known vectors of '*Ca.* P. australiense' are the planthoppers *Zeoliarus (Oliarus) atkinsoni* and *Z. oppositus*, which occur in New Zealand (Beever et al., 2008; Liefting et al., 2011a; Winks et al., 2014). *Zeoliarus atkinsoni* is monophagous and has only been demonstrated to transmit the phytoplasma between *Phormium* plants, while *Z. oppositus* is polyphagous (Beever et al., 2008; Liefting et al., 2011a), suggesting that *Z. oppositus* may be more important for infecting crop plants (Liefting et al., 2011a). Aside from these two species, it is likely there are multiple other leafhopper and planthopper vectors that have not been identified (Charles et al., 2002; Dermastia et al., 2017; Magarey et al., 2006). The vector responsible for the spread of '*Ca.* P. australiense' in Australia is unknown (Liefting et al., 2011a). See the Known Vectors section for more information.

'*Ca.* P. australiense' can also be spread by cuttings, grafting, storage tubers, rhizomes, or bulbs (Lee et al., 2000). Notably in grapevines, attempts to transmit '*Ca.* P. australiense' by cuttings and grafts have been unsuccessful, suggesting that grapevine may be a terminal host (Magarey et al., 2006). Transmission has been shown from mother strawberry plants to daughter plants via runners (stolons), and the disease can therefore be spread in planting material to fruit production farms (Streten et al., 2005c).

Evidence suggests that wild and weedy species may be important reservoir hosts of '*Ca.* P. australiense'. '*Candidatus* Phytoplasma australiense' has been detected in wild plant species in the vicinity of infected grapevine plants (Magarey et al., 2006). Additionally, in Queensland, Australia, '*Ca.* P. australiense' has been a major problem for strawberry growers and has led to the destruction of 10-50% of strawberry runner plants (Streten et al., 2006). Since strawberry plants are not grown year-round in that area, it suggests that non-crop plant species grown nearby may be reservoirs for the phytoplasma (Streten et al., 2005c). Several wild and weedy species found in Australia and New Zealand are environmental hosts that may act as a reservoir for '*Ca.* P. australiense' (See Potential reservoir hosts) (Andersen et al., 2001; Liefting et al., 1998; Magarey et al., 2006).

Known Hosts

Known hosts include unmanaged/wild species and globally distributed commercial crops and ornamental plants. Economically important hosts include grape, papaya, and strawberry, based on their history of yield losses (Table 1). Riparian vegetation, swamplands, neighboring wastelands, and other adjacent habitat are theorized to act as an inoculum reservoir for commercially important hosts (Constable et al., 2004; Dermastia et al., 2017; Magarey et al., 2006). Possible reservoir host species are listed below (Table 2) and include both plants native to Australia and New Zealand and several species that are common in the United States (Habili et al., 2007; Saqib et al., 2006; USDA-FS, 2014).

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) have primary evidence for feeding and damage documented in the literature. Plants are highlighted in bold if they are commercially produced and the pest causes economically significant damage.

‘*Ca.* P. australiense’ has been detected in the following hosts:

Table 1. Cultivated Hosts

Scientific name	Common name	Reference
*Apium graveolens**	celery	Liefting et al., 2011a; Liefting et al., 2011b
Carica papaya*	**papaya**	**Gibb et al., 1996; White et al., 1998**
*Cordyline australis**	cabbage tree	Andersen et al., 2001
*Cucurbita maxima**	pumpkin	Streten et al., 2005a
*Cucurbita moschata**	butternut squash	Streten et al., 2005a
Fragaria* x *ananassa*	**strawberry**	**Andersen et al., 1998; Queensland Government, 2022; Streten et al., 2005d**
*Liquidambar styraciflua**	sweetgum	Habili et al., 2007
Medicago sativa	**alfalfa**	**Gurr et al., 2007**
*Paulownia fortunei**	dragontree	Bayliss et al., 2005
Phormium cookianum	mountain flax	Liefting et al., 1996; Liefting et al., 1998
*Phormium tenax**	New Zealand flax	Liefting et al., 1996
*Rubus ursinus**	boysenberry	Liefting et al., 2011a
Solanum tuberosum*	**potato**	**Liefting et al., 2011a; Liefting et al., 2011b**
Trifolium spp.*	clover	Saqib et al., 2006
Vitis vinifera*	**grape**	**Constable et al., 2011**

* Hosts with known U.S. distribution

Table 2. Potential reservoir hosts

Scientific name	Common name	Reference
Coprosma robusta	karamu	Beever et al., 2004
*Cucumis myriocarpus**	paddy melon	Saqib et al., 2006
Einadia nutans	climbing saltbush	Magarey et al., 2006
*Enchylaena tomentosa**	ruby saltbush	Magarey et al., 2006
*Euphorbia terracina**	false caper	Magarey et al., 2006
Gomphocarpus fruticosa	cottonbush, swan plant	Streten et al., 2005c
Jacksonia scoparia	winged broom pea	Streten et al., 2005c
Maireana brevifolia	yanga bush	Magarey et al., 2006

* Hosts with known U.S. distribution

‘*Ca.* P. australiense’ was erroneously reported on peach in Bolivia due to misclassification of the 16S rRNA gene sequence (Bekele et al., 2011; Davis, 2013; Jones et al., 2005).

Pest Importance

‘*Ca.* P. australiense’ affects economically important crops such as grape, strawberry, papaya, and alfalfa. In grape, disease incidence as high as 73% has been reported (Constable et al., 2004), and yield losses greater than 30% have been reported (Dermastia et al., 2017; Magarey et al., 2006). Outbreaks of papaya dieback, caused by ‘*Ca. P. australiense’,* have caused annual losses of 10% in Australia, and have destroyed whole papaya crops in Northern and Western Australia, causing many growers to discontinue production altogether (Streten et al., 2006; White et al., 1998).

Strawberry lethal yellows, caused by '*Ca.* P. australiense' was reported to be a persistent problem in New Zealand, and outbreaks in Queensland, Australia, have led to the destruction of 10-50% of strawberry runners (Charles et al., 2002; Streten et al., 2006). In alfalfa, Australian lucerne yellows disease, caused in part by '*Ca.* P. australiense', can reduce seed yield, resulting in an estimated loss of $7 million annually to the alfalfa seed industry in parts of Australia (Pilkington et al., 1999; Streten et al., 2006). *Phormium tenax* was used for the fiber industry in New Zealand and '*Ca.* P. australiense' contributed to the collapse of this industry (Liefting et al., 1996; Liefting et al., 1998). The importance of '*Ca.* P. australiense' infection in boysenberry is currently unclear because it often co-infects with the fungus *Cercosporella rubi*, which causes boysenberry decline disease (Liefting et al., 2011a; Wood et al., 1999). '*Ca.* P. australiense' has also been identified as a causal agent of pumpkin yellow leaf curl disease in Australia (Streten et al., 2005a). Although reports of this disease are limited and its associated yield losses are unclear, pumpkin may be an important host to survey because it is often grown in close proximity to papaya and strawberry, hosts that suffer severe losses when infected with this phytoplasma (Streten et al., 2005a).

In the United States, grape and strawberry are the highest value fruit crops with production valued at approximately 6 and 3.3 billion dollars, respectively, in 2022 (USDA-NASS, 2024). In 2023, the United States alfalfa crop was valued at 12.1 billion dollars for forage alone and, in 2022, papaya, which is only grown in Hawaii, was valued at 6 million dollars (USDA-NASS, 2024).

'*Ca.* P. australiense' may also significantly impact the cosmetic value and quality of certain hosts. Potato tubers have failed quality control checks at the processing factory, boysenberry fruit from infected plants were unmarketable (Liefting et al., 2011a; Liefting et al., 2011b), and alfalfa seed has received a poorer grade and a reduction in subsequent seedling emergence (Pilkington et al., 1999). Similarly, we could find no quantitative data on commercial yield losses in celery, but the discoloration of the foliage due to infection with '*Ca.* P. australiense' would render it unmarketable (Liefting et al., 2011b).

There is limited information about the impact of '*Ca.* P. australiense' in potato, but, because potato tubers infected with 'Ca. P. australiense' have failed quality control checks in processing facilities (Liefting et al., 2011a), and because its symptoms are similar to "zebra chip", it may threaten potato production in the United States, which is valued at approximately 5 billion dollars (NASS, 2023; Nischwitz et al., 2015). "Zebra chip" is a disease caused by the psyllid-vectored bacteria '*Ca*. L. solanacearum' and has caused losses up to 100% in potato (Liefting et al., 2009; Nischwitz et al., 2015). It is not yet clear whether '*Ca.* P. australiense' could cause such extreme impacts in this host.

'*Ca.* P. australiense' is listed as a harmful organism in Chile, China, Colombia, Costa Rica, the European Union, Morocco, and Japan (USDA-PCIT, 2024). There may be trade implications with these countries if this pest becomes established in the United States (FAS GATS, 2024).

Known Vectors (or associated insects)

Confirmed vectors of '*Ca.* P. australiense' are the planthoppers *Zeoliarus (Oliarus) atkinsoni* and *Zeoliarus oppositus*, which occur in New Zealand and have not been reported in the United States (Beever et al., 2008; Winks et al., 2014). The vector responsible for the spread of '*Ca.* P. australiense' in Australia is unknown (Liefting et al., 2011a). Since *Zeoliarus* spp. are restricted to New Zealand (NSW DPI, n.d.), vectors of '*Ca*. P. australiense' must span multiple genera.

Other insects that have been associated with and are suspected vectors of '*Ca.* P. australiense' include *Arawa variegata* (Charles et al., 2002), *Batracomorphus angustatus* (Magarey et al., 2006)*, Orosius argentatus* (Magarey et al., 2006)*,* and *Recilia hospes* (Charles et al., 2002)*.* There are likely additional leafhopper and planthopper species which have yet to be identified as vectors for this phytoplasma (Charles et al., 2002; Dermastia et al., 2017; Magarey et al., 2006). Many phytoplasmas are transmitted by several insect vectors; a single vector may transmit multiple phytoplasma species (Gonella et al., 2019). There are numerous leafhopper and planthopper species in the United States (Tjosvold et al., 2022; University of Delaware, 2024) and it is currently unknown if these can transmit '*Ca.* P. australiense'.

Known Distribution

This species is likely native to:
Oceania: Australia and New Zealand (Davis et al., 1997; Davis et al., 2006; Liefting et al., 1998).

This species has also been detected in:
Oceania: New Caledonia (Davis et al., 2006; Liefting et al., 1998).

'*Ca.* P. australiense has been erroneously reported from Israel and Bolivia (Bekele et al., 2011; Davis, 2013; Gera et al., 2005; Jones et al., 2005).

Pathway

'*Ca.* P. australiense' cannot survive outside of its hosts (Bertaccini et al., 2009). Insect vectors transmit the phytoplasma to host plants (Beever et al., 2008; Winks et al., 2014). It can also spread through infected plants, such as nursery stock, grafting, cuttings, storage tubers, rhizomes and bulbs (Beever et al., 2008; Dermastia et al., 2017; Magarey et al., 2006; Pilkington et al., 1999; Streten et al., 2005a; Winks et al., 2014). The extent to which seed transmission of phytoplasmas occurs is controversial, though '*Ca.* P. australiense' was reported to be seed borne in alfalfa (Gurr et al., 2007; Satta et al., 2019).

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.

Agricultural Commodity Import Requirements(ACIR) manual: ACIR provides a single source to search for and retrieve entry requirements for imported commodities. https://acir.aphis.usda.gov/s/

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

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

The known distribution of this phytoplasma corresponds to plant hardiness zones 8-13 (Takeuchi et al., 2018). Since '*Ca.* P. australiense' has a wide host range, all 50 states produce several crops that could be potential hosts. Diseased grapevine shoots have been observed to grow back normally after 1-2 days of daily maximum temperatures greater than 100 °F, conditions which are likely to kill or greatly reduce the titer of the pathogen (Magarey et al., 2006). Therefore, '*Ca.* P. australiense' may be less problematic in areas that commonly exceed this temperature. California, Oregon, and Washington are amongst the top producers of several important host crops (alfalfa, grape, potato, and strawberry) (USDA-NASS, 2024; USDA-NRCS, 2024).

Considering climate suitability and host availability, the following areas are endangered and grow three or more of the host crops: Alabama, Arkansas, Arizona, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, Nevada, New Mexico, North Carolina, Oklahoma, Oregon, South Carolina, Texas, Washington, and Puerto Rico. Emphasis should be placed on areas where alfalfa, cucurbits, grape, potato, papaya, strawberry, and sweetgum are common.

Known vectors of '*Ca.* P. australiense' are the planthoppers *Zeoliarus (Oliarus) atkinsoni* and *Z. oppositus*, which are not known to occur in the United States (Beever et al., 2008; Winks et al., 2014). It is suspected that there may be additional vectors, though these have not been characterized (Magarey et al., 2006). The suspected vector *Recilia hospes* has been reported from Hawaii (Charles et al., 2002).

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://approvedmethods.ceris.purdue.edu/.

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Versions

January 2013 (Version 1): Datasheet completed.

June 2013 (Version 1.1): Added Solanaceous host information.

June 2014 (Version 1.2): Added link to CAPS symptomatic screening aid in Symptoms/Signs and Survey section.

July 2014 (Version 1.3): Fixed link in document to the phytoplasma sample submission document.

November 2014 (Version 1.4): Fixed a few links in the document.

June 2016 (Version 1.5): Added new phytoplasma sample submission information to survey and diagnostic sections.

March 2024 (Version 2)
- Converted to new template (Template Version 2.3)
- Included 16SrXII-B classification, removed **Synonyms** and **Common Names** for strains that no longer meet the criteria for species inclusion.
- Added **Notes on taxonomy and nomeclature**
- Revised **Pest Recognition**, including Pest Description, updated and added more details on symptoms by host
- Added **Easily Mistaken Species**
- Revised **Pest Importance, Known Vectors, Pathway**
- Added Iran and New Caledonia to **Known Distribution**
- Revised **Potential Distribution** to account for plant hardiness zones.
- Revised **Survey and Key Diagnostics** to matching new AMPS format and included language for survey recommendations, time of year to survey, survey design, site inspection.
- Added iPhyClassifier to **Identification Resources**
- Added North American grapevine yellows to **Mistaken Identities.**

Reviewer(s)

Dr. Lia Liefting, Principal Scientist, Biosecurity New Zealand
Dr. Stefano Costanzo, Research Plant Pathologist, USDA-ARS-NEA
Dr. Peter Magarey, Plant Pathologist, Magarey Plant Pathology