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

‘Candidatus Phytoplasma prunorum’

‘*Candidatus* Phytoplasma prunorum’ Seemüller and Schneider, 2004

Synonym(s):
None

Common Names

European stone fruit yellows, plum leptonecrosis, apricot decline, peach decline, apricot dieback, peach yellows, peach vein clearing, apricot chlorotic leafroll

Type of Pest

Phytoplasma

Taxonomic Position

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

Pest Recognition

Pest Description

Phytoplasmas belong to the class Mollicutes and are the putative causal agents of yellows diseases that affect at least 1,000 plant species worldwide (McCoy et al., 1989; Seemuller et al., 2002; Trivellone and Dietrich, 2020). These minute, endocellular prokaryotes colonize the phloem of their infected plant hosts as well as various tissues and organs of their respective insect vectors. Phytoplasmas are transmitted after a latency period of several days to months to plants during feeding activity by their vectors, primarily leafhoppers, planthoppers, and psyllids in the order of Hemiptera (IRPCM, 2004; Thébaud et al., 2009).

Phytoplasmas are classified in a system of groups and subgroups based on DNA fingerprints of their 16S rRNA genes (16S rDNA) (Lee et al., 1995; Lee et al., 2000). ‘*Candidatus* Phytoplasma prunorum’ is classified in the apple proliferation group (16SrX), subgroup B (16SrX-B). The 16SrX group also includes phytoplasmas associated with other perennial fruit tree diseases present in Europe, including apple proliferation (‘*Candidatus* Phytoplasma mali’) and pear decline (‘*Candidatus* Phytoplasma pyri’) (Seemüller and Schneider, 2004).

Symptoms

‘Candidatus Phytoplasma prunorum’ is associated with the European stone fruit yellows (ESFY) disease, which primarily includes diseases of apricot, Japanese plum, and peach. Symptoms of ESFY are influenced by *Prunus* species, cultivar, age of trees, rootstock, and environmental factors. There are many tolerant hosts that do not show any symptoms of disease but can harbor infections that are reservoirs for further transmission of this disease (Németh, 1986).

Figure 1. Premature leaf emergence in an infected *Prunus salicina* (Japanese plum) tree (left), and phloem necrosis (right) in a *Prunus* spp. affected by ESFY. Photos are courtesy of Assumpcio Batlle, IRTA, Catalunya, Spain (left), and Dr. B. Schneider, BBA (right).

A common symptom of infection in most *Prunus* species is the early break of leaf buds in late winter (Fig. 1) (Jarausch et al., 2008). The early break in dormancy increases the susceptibility of affected trees to frost, which can damage the phloem (Fig. 1). Infected shoots are typically shorter and bear smaller, deformed leaves that can drop prematurely. Infected shoots may die back, and fruit on affected branches develops poorly and may fall prematurely (Morvan, 1977; Németh, 1986). Infected apricot and Japanese plum trees display leaf rolling and yellowing (Fig. 2-3) followed by leaf reddening (Fig. 4), small leaves, or suppression of dormancy leading to the risk of frost injury, necrosis, tree decline, and eventual death (Carraro and Osler, 2003; Morvan, 1977). Peaches exhibit early leaf reddening, severe upward longitudinal rolling of leaves, brittle leaves, abnormal thickening of the midribs and primary veins, autumnal growth of latent buds, which produce tiny chlorotic leaves and sometimes flowers, and early leaf fall (Poggi Pollini et al., 2001). In Italy, symptoms first appeared in late summer with latent bud production occurring in September (Poggi Pollini et al., 2001). ESFY also affects tree flowers and shoots in winter, which leads to lack of fruit production (Fig. 5) and chlorosis of leaves later in the growing season (Gazel et al., 2009).

Easily Mistaken Species

Symptoms of phytoplasma infection may resemble symptoms caused by other plant pathogens or abiotic stress; molecular identification is necessary to confirm the presence of a phytoplasma. Some phytoplasmas in North America have similar host ranges as ‘*Ca*. P. prunorum’ and cause similar symptoms. The peach yellow leaf roll (PYLR) phytoplasma, which also belongs in the 16SrX group (subgroup C), is present in California (Gasparich et al., 2020; Kison et al., 1997). ‘*Candidatus* Phytoplasma pruni’, which infects stone fruit in North America, is part of the16SrIII group (the Western-X disease group), and symptoms of X-disease infection are similar to those of ESFY infection (Lee et al., 1998; Marcone et al., 2010; Poggi Pollini et al., 2001).

Figure 2. Leaf rolling symptom of ESFY in apricot. Photo courtesy of G. Morvan. EPPO.

Biology and Ecology

ESFY is considered an epidemic disease since it can spread rapidly when environments are favorable to the growth of host plants and vectors (Carraro and Osler, 2003). *Cacopsylla pruni* (plum psyllid) is the primary vector of '*Ca*. P. prunorum' (Carraro et al., 1998b). This psyllid completes one generation per year and overwinters as an adult on shelter plants, usually conifers in highland areas (Conci et al., 1992; Thébaud et al., 2009). At the end of winter, *C. pruni* moves from shelter plants to cultivated or wild *Prunus* species for oviposition. From May until early July, the new generation feeds on *Prunus* species. As soon as adult development is complete, *C. pruni* abandons the stone fruit trees (Carraro et al., 2001; Conci et al., 1992) and migrates back to shelter plants to overwinter (Thébaud et al., 2009). During this time, the phytoplasma colonizes and multiplies in the insect's salivary glands (Thébaud et al., 2009). *Cacopsylla pruni* remains infective through overwintering and into the following spring. After the eight-month overwintering period, *C. pruni* has a transmission efficiency of 60% (Thébaud et al., 2009).

Figure 3. Apricot tree showing symptoms of yellowing, leaf curl, and decline (top), and a symptomless shoot (bottom). Image from Davies and Adams (2000).

When overwintered insects reach the stone fruit trees, they are already infected and infective (Carraro et al., 2001). The natural transmission period lasts as long as the vector is present on *Prunus* species (Carraro et al., 2004b). The psyllid transmits '*Ca*. P. prunorum' in a persistent-propagative manner (Thébaud et al., 2009). According to one study, infected stone fruit plants showed typical ESFY symptoms after an incubation period of 4-5 months (Carraro et al., 1998b). '*Candidatus* Phytoplasma prunorum' can persist in the stem of *Prunus* hosts in the dormant winter season, in sharp contrast to the apple proliferation and pear decline phytoplasmas, which only survive winter in host roots (Seemüller et al., 1998).

Figure 4. Reddening of Japanese plum leaves affected by ESFY (right) compared to an unaffected leaf (left). Photo courtesy of Dr. B. Schneider, BBA.

Studies have demonstrated the important role of wild *Prunus* species in the spread of ESFY. These plants serve as hosts for the vector and the phytoplasma in the epidemic cycle of the disease (Carraro et al., 2002; Jarausch et al., 2019; Thébaud et al., 2009). The phytoplasma can, therefore, survive and persist in nature without cultivated hosts. In Europe, *C. pruni* prefers *Prunus spinosa* (blackthorn) for its development (Lauterer, 1999). This psyllid may also be found on numerous other wild and/or cultivated *Prunus* species (Carraro et al., 2004a; Gallinger et al., 2020).

Known Hosts

'Candidatus Phytoplasma prunorum' is prevalent in areas where susceptible hosts, the vector, and favored wild hosts of the vector are available (Steffek et al., 2012). On its susceptible and sensitive hosts – apricot, Japanese plum, and peach - the symptoms of ESFY infection are visible. However, other stone fruit species may not show symptoms due to tolerance or resistance (Morvan, 1977). Wild hosts such as *P. spinosa* and *P. cerasifera* are usually symptomless (Carraro et al., 2004a; Carraro et al., 1998a; Jarausch et al., 1999; Jarausch et al., 2000a).

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.

Major Hosts: *Prunus armeniaca* (apricot) *, *Prunus cerasifera* (cherry plum)*, , ***Prunus persica* (peach)***, ***Prunus salicina* (Japanese plum)***, and *Prunus spinosa* (blackthorn)* (Carraro et al., 1992; Jarausch et al., 2008; Morvan, 1977; Poggi Pollini et al., 2001).

Other Known Hosts: *Celtis australis* (European hackberry)*, *Convolvulus arvensis* (field bindweed)*, *Corylus avellana* (European hazel)*, *Cynodon dactylon* (Bermudagrass)*, *Fraxinus excelsior* (European ash)*, *Prunus americana* (American

* Host with known U.S. distribution.

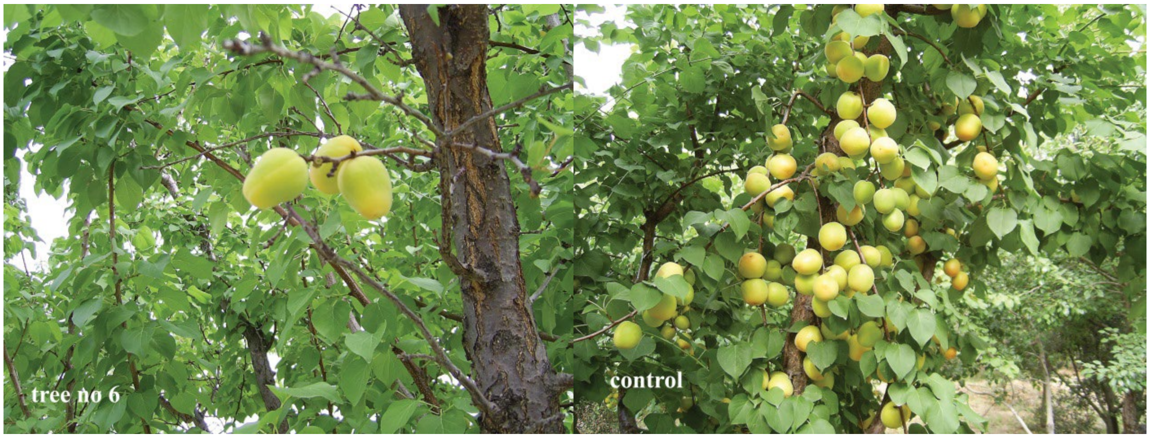

Figure 5: Fruit set of '*Ca.* Phytoplasma prunorum' infected apricot tree (left) compared with a healthy control tree (right). Image is from Gazel et al. (2009).

plum)*, *Prunus dulcis (=Prunus amygdalus)* (sweet almond)*, *P. avium* (sweet cherry)*, *P. bokhariensis* (Bokhara plum), *P. brigantina* (Briançon apricot), *P. cerasus* (sour cherry)*, *P. coccomilia* (Italian plum), *P. consociiflora* (Chinese wild peach), *P. dasycarpa* (purple, black apricot)*Prunus domestica* (European plum)*, *Prunus serrulata* (flowering cherry)*, *P. mahaleb* (Mahaleb cherry)*, *P. maritima* (beach plum)*, *P. mexicana* (Mexican plum)*, *P. mume* (Japanese apricot)*, *Prunus orthosepal*, *P. salicina* x *cerasifera* (methley, cherry plum), *P. serrulata* (Japanese flowering cherry)*, *P. simonii* (apricot plum), , *P. subcordata* (Klamath plum)*, *P. tomentosa* (Nanking cherry)*, *Pyrus* spp. (pear)*, *Rosa canina* (dog rose)*, and *Vitis vinifera* (grape)* (Carraro et al., 2002; Carraro et al., 2004a, 2004b; Carraro and Osler, 2003; Carraro et al., 1992; Fialová et al., 2004; Giunchedi et al., 1982; Hashemi-Tameh et al., 2014; Jarausch et al., 1999; Jarausch et al., 2000a; Jarausch et al., 2001; Jarausch et al., 1998; Jarausch et al., 2000b; Kison and Seemüller, 2001; Lorenz et al., 1994; Marcone et al., 1996a; Morvan, 1977; Pignatta et al., 2008; Poggi Pollini et al., 2001; Poggi Pollini et al., 1995; Sánchez-Capuchino et al., 1976; Varga et al., 2000).

Note: The level of susceptibility and symptom expression varies significantly among 'other' hosts.

'*Candidatus* Phytoplasma prunorum' also causes infection of *Prunus* rootstocks: *Prunus besseyi* x *P. hortulana, P. cerasifera*, *P. domestica*, *P. domestica* x *P. cerasifera*, *P. mariana*, *P. persica* x *P. cerasifera,* and *P. salicina* x *P. spinosa* (Jarausch et al., 1998; Jarausch et al., 2000b; Kison and Seemüller, 2001). The susceptibility and sensitivity of the rootstocks to ESFY varies according to the different genotypes. Some are highly sensitive, including apricot seedlings and peach rootstocks Rubira, Montclar and Rutgers Red Leaf. Other rootstocks, such as *P. domestica* stocks Ackermann's, Brompton and P 1275, are tolerant (Kison and Seemüller, 2001).

Pest Importance

'*Candidatus* Phytoplasma prunorum' causes economic damage to apricot (Desvignes and Cornaggia, 1982), Japanese plum (Marcone et al., 2010), and peach (Marcone et al., 1996b; Poggi Pollini et al., 2001). On Japanese plum, incidence of ESFY was reported to be as high as 80 percent (Sabaté et al., 2016). Mortality caused by ESFY can reach up to 100 percent within the most sensitive cultivars in apricot and Japanese plum orchards (Fig. 6), and total yield loss may occur (Carraro and Osler, 2003). In Turkey, susceptible young apricot and plum trees infected with '*Ca.* Phytoplasma prunorum' die quickly (within 1 to 2 years after infection), and the pathogen causes yield and quality losses on trees older than five years (Gazel et al., 2009).

Figure 6: Host mortality of *Prunus salicina* (Japanese plum) trees infected by '*Ca*. P. prunorum'. Photos courtesy of Assumpcio Batlle, IRTA, Catalunya, Spain.

Apricot, peach and nectarine, and plum are all important crops in the United States. In 2020, total production of peaches and nectarine in the United States was at 740,260 tons with a value of $ 642 million and U.S. apricot production was about 33,400 tons with a value of $34 million. In 2020, the United States produced 105,000 tons of fresh plums harvested from 13,800 acres with a total value of $122 million. The United States also produced 57,200 tons of prunes (dried plums) from 40,000 acres with a value of $112 million (NASS, 2021).

'*Candidatus* Phytoplasma prunorum' is listed as a harmful organism in Colombia, Chile, Ecuador, Honduras, Japan, Mexico, and Peru (APHIS, 2021). There may be trade implications with these countries if this pathogen becomes established in the United States.

Known Vectors (or associated insects)

Cacopsylla pruni (Fig. 7) is the only confirmed vector of '*Ca. P*. prunorum' (Carraro et al., 1998b). There are two non-hybridizing species with similar morphology, but with distinct genetic differences (Peccoud et al., 2013); species A and B, both are vectors of the pathogen (Marie-Jeanne et al., 2020; Sauvion et al., 2021). However, the difference of transmission capacity/efficiency between them has not yet been determined. *Cacopsylla pruni* is native to Europe and widespread in the Western Palearctic (Ouvrard, 2021; Steffek et al., 2012).

Figure 7. *Cacopsylla pruni*. Photo courtesy of B. Jarausch. RLP AgroSciences.

Asymmetrasca decedens (=*Empoasca decendens*) was tentatively shown to transmit

ESFY on two apricot trees (Pastore et al., 2004), but in another study, it did not spread the phytoplasma in an apricot orchard during several years of monitoring (Pastore et al., 2010). The leafhoppers *Anaceratogallia* and *Euscelis* have been infected by the phytoplasma, but are not confirmed vectors (Poggi Pollini et al., 1996).

Cacopsylla pruni and *Asymmetrasca decendens* are not currently known to be present in the United States.

Known Distribution

Africa: Egypt, Tunisia. **Asia:** Azerbaijan, Iran, Turkey. **Europe:** Albania, Austria, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, France (including Corsica), Germany, Greece, Hungary, Italy (including Sardinia), Netherlands, Poland, Romania, Serbia, Slovakia, Slovenia, Spain, Switzerland, and the United Kingdom (England) (Al Khazindar and Abdel Salam, 2011; Ambrožič Turk et al., 2008; Balakishiyeva et al., 2010; Bissani et al., 2002; Carraro et al., 1998a; Cieślińska and Morgaś, 2011; Davies and Adams, 2000; Delic et al., 2007; Duduk et al., 2004; EPPO, 2021; Etropolska and Lefort, 2019; Fialova et al., 2007; Gazel et al., 2009; Hashemi-Tameh et al., 2014; Holevas et al., 2000; Ivic et al., 2017; Jarausch et al., 2008; Jarausch et al., 1998; Jarausch et al., 2000b; Khalifa et al., 2011; Koncz et al., 2017; Križanac et al., 2010; Laimer Da Câmara Machado et al., 2001; Marie-Jeanne et al., 2020; Mehle et al., 2007; Myrta et al., 2003; Navrátil et al., 2001; Necas et al., 2018; Olivier et al., 2004; Polak et al., 2007; Ramel and Gugerli, 2003; Riedle-Bauer et al., 2019; Sabaté et al., 2016; Sertkaya et al., 2005; Topchiiska et al., 2000; Trandafirescu et al., 2011; Valasevich and Schneider, 2016; Verbeek, 2008).

The incidence of disease varies in each country. ESFY is a serious problem in countries bordering the Mediterranean Sea (Spain, France, Italy, Balkans) where the cultivation of susceptible and sensitive *Prunus* species is widespread (Steffek et al., 2012). This phytoplasma is considered to be no longer present in Cyprus; records from South Africa and Ukraine are considered to be invalid (EPPO, 2021).

Pathway

Long-distance spread occurs when infected plant material, especially symptomless plant material, is transported to a new area (Carraro et al., 1992; Marcone et al., 2010; Seemüller et al., 1998). ‘*Candidatus* Phytoplasma prunorum’ is easily transmissible by budding and grafting in summer and winter (Riedle-Bauer et al., 2012). Imported plant materials were considered as a main means of introduction of ‘*Ca*. P. prunorum’ into Turkey (Ulubaş Serçe et al., 2006). Local spread of ‘*Ca.* P. prunorum’ may occur from the flight of the insect vector. Infectious *C. pruni* may spread the phytoplasma to *Prunus* spp. over long distances (27-50 km) during its adult lifespan (Marie-Jeanne et al., 2020; Thébaud et al., 2009).

According to Federal Order DA-2013-18, effective May 20, 2013, the import of *Prunus* spp. propagative material is currently prohibited from all countries except Canada and the Netherlands to restrict import of host material of *Anoplophora chinensis* (Chinese longhorned beetle) and *Anoplophora glabripennsis* (Asian longhorned beetle) (USDA, 2021). Prior to this Federal Order, import of *Prunus* spp. propagative material was allowed from the following countries known to have ‘*Ca*. P. prunorum’: Belgium, France, Germany, and the United Kingdom (USDA, 2021).

Since 2016, there have been shipments of *Prunus* spp. propagative material from the following countries where ‘*Ca*. P. prunorum’ is present: Albania (14), Belgium (1), Bulgaria (1), Croatia (1), Czech Republic (7), Egypt (1), France (19), Germany (34), Greece (5), Hungary (11), Iran (4), Italy (17), Netherlands (12), Poland (3), Romania (1), Spain (17), Tunisia (3), Turkey (29), the United Kingdom (17). The largest of these shipments was from the Netherlands and contained 10,000 plant units (ARM, 2021). There have also been 34 interceptions of *Prunus* spp. plant material intended for propagation from 12 different countries where *‘Ca.* P. prunorum’ is present since 2016 (ARM, 2021).

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 drop down 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

Based on the known distribution of '*Ca.* P. prunorum', it may establish in plant hardiness zones 4-11, which encompass most of the continental United States (Takeuchi et al., 2018). Orchards where apricot, Japanese plum, and peaches are grown are most vulnerable to damage. California has the greatest risk of economic damage from this phytoplasma based on host presence. About 90 percent of U.S. apricot production occurs in California, and the rest occurs in Washington State (NASS, 2021). The top five states for peach production are California (47.9 %), South Carolina (20.5%), Georgia (12.0%), New Jersey (5.2%), and Pennsylvania (5.1%) (NASS, 2021). Production of nectarine (13,600 acres) and plum (13,800 acres) is limited, mostly, to California (NASS, 2021). Most of the continental United States has a fairly low level of risk of economic damage from '*Ca*. Phytoplasma prunorum' establishment based on host availability. Important wild hosts for the vector and the ESFY phytoplasma, such as *Prunus spinosa* and *P. cerasifera,* are also present in eastern and western United States (NRCS, 2021).

Survey and Key Diagnostics

Approved Methods for Pest Surveillance*

For currently 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.

References

Al Khazindar, M., and A. Abdel Salam. 2011. Phytoplasma in stone fruits and date palm in Egypt. Pages 23-24 *in* COST Action FA0807. Emerging phytoplasma diseases of stone fruits and other crops and their possible impact on EU Countries, Istanbul, Turkey.

Ambrožič Turk, B., N. Mehle, J. Brzin, V. Škerlavaj, G. Seljak, and M. Ravnikar. 2008. High infection pressure of ESFY phytoplasma threatens the cultivation of stone fruit species. Journal of Central European Agriculture 9(4):795-801.

APHIS. 2021. Phytosanitary Export Database (PExD). United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). https://pcit.aphis.usda.gov/pcit/faces/signIn.jsf.

ARM. 2021. Agriculture Risk Management (ARM) Data Mart. Diagnostic Request Detail. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine.

Balakishiyeva, G., J. Danet, M. Qurbanov, A. Mamedov, A. Kheyr-Pour, and X. Foissac. 2010. First report of phytoplasma infections in several temperate fruit trees and vegetable crops in Azerbaijan. Journal of Plant Pathology 92(4 Supplement):S115.

Bissani, R., A. Franceschini, L. Maddau, S. Serra, C. Poggi Pollini, and F. Terlizzi. 2002. First report of European stone fruit yellow phytoplasma (ESFYP) in Sardinia (in Italian). Pages 577-582 *in* Atti, Giornate fitopatologiche, Baselga di Piné. Università degli Studi di Bologna, Trento, Italy.

Carraro, L., F. Ferrini, P. Ermacora, and N. Loi. 2002. Role of wild *Prunus* species in the epidemiology of European stone fruit yellows. Plant Pathology 51(4):513-517.

Carraro, L., F. Ferrini, P. Ermacora, and N. Loi. 2004a. Transmission of European stone fruit yellows phytoplasma to *Prunus* species by using vector and graft transmission. Pages 449-453 *in* XIX International Symposium on Virus and Virus-like Diseases of Temperate Fruit Crops-Fruit Tree Diseases 657.

Carraro, L., F. Ferrini, G. Labonne, P. Ermacora, and N. Loi. 2004b. Seasonal infectivity of *Cacopsylla pruni*, vector of European stone fruit yellows phytoplasma. Annals of Applied Biology 144(2):191-195.

Carraro, L., N. Loi, and P. Ermacora. 2001. Transmission characteristics of the European stone fruit yellows phytoplasma and its vector *Cacopsylla pruni*. European Journal of Plant Pathology 107(7):695-700.

Carraro, L., N. Loi, P. Ermacora, and R. Osler. 1998a. High tolerance of European plum varieties to plum leptonecrosis. European Journal of Plant Pathology 104(2):141-145.

Carraro, L., and R. Osler. 2003. European stone fruit yellows: a destructive disease in the Mediterranean basin. Options Méditerranéennes, Série B 45:113-117.

Carraro, L., R. Osler, N. Loi, P. Ermacora, and E. Refatti. 1998b. Transmission of European stone fruit yellows phytoplasma by *Cacopsylla pruni*. Journal of Plant Pathology:233-239.

Carraro, L., R. Osler, E. Refatti, and M. Favali. 1992. Natural diffusion and experimental transmission of plum “leptonecrosis”. Pages 285-290 *in* XV International Symposium on Fruit Tree Diseases 309.

Cieślińska, M., and H. Morgaś. 2011. Detection and identification of ‘*Candidatus* Phytoplasma prunorum’, ‘*Candidatus* Phytoplasma mali’ and ‘*Candidatus* Phytoplasma pyri’ in stone fruit trees in Poland. Journal of Phytopathology 159(4):217-222.

Conci, C., C. Rapisarda, and L. Tamanini. 1992. Annotated catalogue of the Italian Psylloideae. first part (insecta Homoptera). Atti dell’Accademia Roveretana degli Agiati 2 B (ser. VII):107-108.

Contaldo, N., F. D’Ercoli, C. Castaneda, and A. Bertaccini. 2018. Detection and identification of phytoplasmas in two vineyards located in a restricted geographic area in Italy. University of Bologna, Bologna, Italy.

Davies, D. L., and A. N. Adams. 2000. European stone fruit yellows phytoplasmas associated with a decline disease of apricot in southern England. Plant Pathology 49(5):635-639.

Davis, R. E., Y. Zhao, E. L. Dally, I.-M. Lee, R. Jomantiene, and S. M. Douglas. 2013. ‘*Candidatus* Phytoplasma pruni’, a novel taxon associated with X-disease of stone fruits, *Prunus* spp.: multilocus characterization based on 16S rRNA, secY, and ribosomal protein genes. International Journal of Systematic and Evolutionary Microbiology 63(Pt_2):766-776.

Delic, D., M. Martini, P. Ermacora, A. Myrta, and L. Carraro. 2007. Identification of fruit tree phytoplasmas and their vectors in Bosnia and Herzegovina. EPPO Bulletin 37(2):444-448.

Desvignes, J., and D. Cornaggia. 1982. Observations on apricot chlorotic leaf roll (ACLR): sensitiveness of different *Prunus* species, detection, spread in plum

orchards. Pages 249-256 *in* XII International Symposium on Fruit Tree Virus Diseases 130.
Duduk, B., S. Botti, M. Ivanović, B. Krstić, N. Dukić, and A. Bertaccini. 2004. Identification of phytoplasmas associated with grapevine yellows in Serbia. Journal of Phytopathology 152(10):575-579.
EPPO. 2021. EPPO Global Database and GD Desktop. https://gd.eppo.int/.
Etropolska, A., and F. Lefort. 2019. First report of *Candidatus* Phytoplasma prunorum, the European Stone Fruit Yellows Phytoplasma on peach trees on the territory of Canton of Geneva, Switzerland. International Journal of Phytopathology 8(2):63-67.
Fialova, R., M. Navratil, P. Lauterer, and V. Navrkalova. 2007. Candidatus Phytoplasma prunorum': the phytoplasma infection of Cacopsylla pruni from apricot orchards and from overwintering habitats in Moravia (Czech Republic). Bulletin of Insectology 60(2):183.
Fialová, R., M. Navrátil, P. Válová, P. Lauterer, F. Kocourek, and Z. Poncarová-Voráč. 2004. Epidemiology of European stone fruit yellows phytoplasma in the Czech Republic. Pages 483-487 *in* XIX International Symposium on Virus and Virus-like Diseases of Temperate Fruit Crops-Fruit Tree Diseases 657.
Gallinger, J., B. Jarausch, W. Jarausch, and J. Gross. 2020. Host plant preferences and detection of host plant volatiles of the migrating psyllid species *Cacopsylla pruni*, the vector of European Stone Fruit Yellows. Journal of Pest Science 93(1):461-475.
Gasparich, G. E., A. Bertaccini, and Y. Zhao. 2020. '*Candidatus* Phytoplasma'. Pages 1-39 Bergey's Manual of Systematics of Archaea and Bacteria. John Wiley and Sons.
Gazel, M., K. Caglayan, C. U. Serce, and L. Son. 2009. Evaluations of apricot trees infected by *Candidatus* Phytoplasma prunorum for horticultural characteristics. Romanian Biotechnological Letters 14(1):4123-4129.
Giunchedi, L., C. Poggi-Pollini, and R. Credi. 1982. Susceptibility of stone fruit trees to the Japanese plum-tree decline causal agent. Pages 285-290 *in* XII International Symposium on Fruit Tree Virus Diseases 130.
Hashemi-Tameh, M., M. Bahar, and L. Zirak. 2014. Molecular characterization of phytoplasmas related to apple proliferation and aster yellows groups associated with pear decline disease in Iran. Journal of Phytopathology 162(10):660-669.
Holevas, C. D., A. Chitzanidis, A. C. Pappas, E. C. Tzamos, K. Elena, P. G. Psallidas, A. S. Alivizatos, C. G. Panagopoulos, P. E. Kyriakopoulou, and F. P. Bem. 2000. Disease agents of cultivated plants observed in Greece from 1981 to 1990. Annales de l'Institut phytopathologique Benaki 19(1):1-96.
IRPCM. 2004. '*Candidatus* Phytoplasma', a taxon for the wall-less, non-helical prokaryotes that colonize plant phloem and insects. International Journal of Systematic and Evolutionary Microbiology 54(4):1243-1255.
Ivic, D., J. Plavec, and G. Ivancan. 2017. The occurrence of 'Candidatus Phytoplasma prunorum' in apricot orchards in Baranja. Pomologia Croatica 21(1-2):101-106.
Jarausch, B., I. Mühlenz, A. Beck, I. Lampe, U. Harzer, and W. Jarausch. 2008. Epidemiology of European stone fruit yellows in Germany. Pages 417-422 *in*. International Society for Horticultural Science (ISHS), Leuven, Belgium.

Jarausch, W., J. Eyquard, K. Mazy, M. Lansac, and F. Dosba. 1999. High level of resistance of sweet cherry (*Prunus avium* L.) towards European stone fruit yellows phytoplasmas. Advances in Horticultural Science:108-112.

Jarausch, W., J. P. Eyquard, M. Lansac, M. Mohns, and F. Dosba. 2000a. Susceptibility and tolerance of new French *Prunus domestica* cultivars to European stone fruit yellows phytoplasmas. Journal of Phytopathology 148(7-8):489-493.

Jarausch, W., B. Jarausch-Wehrheim, J. L. Danet, J. M. Broquaire, F. Dosba, C. Saillard, and M. Garnier. 2001. Detection and indentification of European stone fruit yellows and other phytoplasmas in wild plants in the surroundings of Apricot chlorotic leaf roll-affected orchards in Southern France. European Journal of Plant Pathology 107(2):209-217.

Jarausch, W., B. Jarausch, M. Fritz, M. Runne, A. Etropolska, and E. Pfeilstetter. 2019. Epidemiology of European stone fruit yellows in Germany: the role of wild *Prunus spinosa*. European Journal of Plant Pathology 154(2):463-476.

Jarausch, W., M. Lansac, C. Saillard, J. Broquaire, and F. Dosba. 1998. PCR assay for specific detection of European stone fruit yellows phytoplasmas and its use for epidemiological studies in France. European Journal of Plant Pathology 104(1):17-27.

Jarausch, W., C. Saillard, J. Broquaire, M. Garnier, and F. Dosba. 2000b. PCR-RFLP and sequence analysis of a non-ribosomal fragment for genetic characterization of European stone fruit yellows phytoplasmas infecting various *Prunus* species. Molecular and cellular Probes 14(3):171-179.

Khalifa, M. B., M. Aldaghi, H. Hacheche, J. Kummert, M. Marrakchi, and H. Fakhfakh. 2011. First report of'*Candidatus* Phytoplasma prunorum'infecting apricots in Tunisia. Journal of Plant Pathology:517-519.

Kison, H., B. C. Kirkpatrick, and E. Seemüller. 1997. Genetic comparison of the peach yellow leaf roll agent with European fruit tree phytoplasmas of the apple proliferation group. Plant Pathology 46(4):538-544.

Kison, H., and E. Seemüller. 2001. Differences in strain virulence of the European stone fruit yellows phytoplasma and susceptibility of stone fruit trees on various rootstocks to this pathogen. Journal of Phytopathology 149(9):533-541.

Koncz, L., M. Ladányi, and G. Nagy. 2017. Severity of symptoms of European stone fruit yellows on different apricot varieties. Review on Agriculture and Rural Development 6(1-2):63-70.

Križanac, I., I. Mikec, Ž. Budinščak, M. Šeruga Musić, and D. Škorić. 2010. Diversity of phytoplasmas infecting fruit trees and their vectors in Croatia. Journal of Plant Diseases and Protection 117(5):206-213.

Laimer Da Câmara Machado, M., S. Paltrinieri, V. Hanzer, W. Arthofer, S. Strommer, M. Martini, M. Pondrelli, and A. Bertaccini. 2001. Presence of European stone fruit yellows (ESFY or 16SrX-B) phytoplasmas in apricots in Austria. Plant Pathology 50(1):130-135.

Lauterer, P. 1999. Results of the investigations on Hemiptera in Moravia, made by the Moravian museum (Psylloidea 2). Acta Musei Moraviae, Scientiae Biologicae (Brno) 84:71-151.

Lee, I.-M., D. E. Gundersen-Rindal, R. E. Davis, and I. M. Bartoszyk. 1998. Revised classification scheme of phytoplasmas based on RFLP analyses of 16S rRNA

and ribosomal protein gene sequences. International Journal of Systematic and Evolutionary Microbiology 48(4):1153-1169.
Lee, I. M., A. Bertaccini, M. Vibio, and D. E. Gundersen. 1995. Detection of multiple phytoplasmas in perennial fruit trees with decline symptoms in Italy. Phytopathology 85:728-735.
Lee, I. M., R. E. Davis, and D. E. Gundersen-Rindal. 2000. Phytoplasma: phytopathogenic mollicutes. Annu Rev Microbiol 54:221-255.
Lorenz, K.-H., F. Dosba, C. Poggi-Pollini, G. Llácer, and E. Seemüller. 1994. Phytoplasma diseases of *Prunus* species in Europe are caused by genetically similar organisms. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz / Journal of Plant Diseases and Protection 101(6):567-575.
Marcone, C., B. Jarausch, and W. Jarausch. 2010. *Candidatus* phytoplasma prunorum, the causal agent of european stone fruit yellows: An overview. Journal of Plant Pathology 92(1):19-34.
Marcone, C., A. Ragozzino, and E. S. Emüller. 1996a. Association of phytoplasmas with the decline of European hazel in southern Italy. Plant Pathology 45(5):857-863.
Marcone, C., A. Ragozzino, and E. Seemüller. 1996b. European stone fruit yellows phytoplasma as the cause of peach vein enlargement and other yellows and decline diseases of stone fruits in southern Italy. Journal of Phytopathology 144(11-12):559-564.
Marie-Jeanne, V., F. Bonnot, G. Thébaud, J. Peccoud, G. Labonne, and N. Sauvion. 2020. Multi-scale spatial genetic structure of the vector-borne pathogen '*Candidatus* Phytoplasma prunorum' in orchards and in wild habitats. Scientific Reports 10(1):5002.
McCoy, R. E., A. Caudwell, C. J. Chang, T. A. Chen, L. N. Chykowski, M. T. Cousin, J. L. Dale, G. T. N. de Leeuw, D. A. Golino, K. J. Hackett, B. C. Kirkpatrick, R. Marwitz, H. Petzold, R. C. Sinha, M. Sugiura, R. F. Whitcomb, I. L. Yang, B. M. Zhu, and S. E. 1989. Plant diseases associated with mycoplasma-like organisms. Pages 546-640 *in* R. F. Whitcomb and J. G. Tully, (eds.). The Mycoplasmas, Vol. 5. Academic Press, New York.
Mehle, N., J. Brzin, J. Boben, M. Hren, J. Frank, N. Petrovič, K. Gruden, T. Dreo, I. Žežlina, and G. Seljak. 2007. Pregled rezultatov določanja fitoplazem na koščičarjih v letih 2000-2006 v Sloveniji. Pages 139-143 *in* The 8th Slovenian Conference on Plant Protection. Narodna in univerzitetna knjižnica, Ljubljana.
Morvan, G. 1977. Apricot chlorotic leaf roll. EPPO Bulletin 7(1):37-55.
Myrta, A., P. Ermacora, B. Stamo, and R. Osler. 2003. Identification of European stone fruit yellows from apricot and Japanese plum in Albania. Options MéditerranéennesSérie.
NASS. 2021. Noncitrus Fruits and Nuts 2020 Summary. United States Department of Agriculture National Agricultural Statistics Service (NASS), Washington, DC.
Navrátil, M., P. Válová, R. Fialová, K. Petrová, Z. Poncarová-Vorácková, J. Fránová, J. Nebesárová, and R. Karesová. 2001. Survey for stone fruit phytoplasmas in the Czech Republic. Pages 377-382 *in*. International Society for Horticultural Science (ISHS), Leuven, Belgium.
Necas, T., T. Kiss, A. Eichmeier, J. Necasova, and I. Ondrasek. 2018. The effect of phytoplasma disease caused by '*Candidatus* Phytoplasma prunorum' on the

phenological and pomological traits in apricot trees. Notulae Botanicae Horti Agrobotanici 46(1):107-114.

Németh, M. 1986. Apricot chlorotic leaf roll. Pages 626-633 *in* A. T. Kiada, (ed.). Virus, mycoplasma, and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, Dordrecht, the Netherlands.

NRCS, U. 2021. The PLANTS Database. National Plant Data Team, http://plants.usda.gov.

Olivier, T., J. Kummert, and S. Steyer. 2004. First detection of European stone fruit yellows phytoplasma (ESFY) in Belgium. Pages 519-521 *in*. International Society for Horticultural Science (ISHS), Leuven, Belgium.

Ouvrard, D. 2021. Psyl'list - The world Psylloidea database, https://www.hemiptera-databases.org/psyllist/

Pastore, M., M. del Vaglio, F. Gervasi, M. Petriccione, S. Paltrinieri, and A. Bertaccini. 2010. Research on the vector of '*Candidatus* Phytoplasma prunorum' in apricot trees in Southern Italy. Pages 525-530 *in*. International Society for Horticultural Science (ISHS), Leuven, Belgium.

Pastore, M., E. Raffone, M. Santonastaso, R. Priore, S. Paltrinieri, A. Bertaccini, and A. M. Simeone. 2004. Phytoplasma detection in *Empoasca decedens* and *Empoasca* spp. and their possible role as vectors of European stone fruit yellows (16SrX-B) phytoplasma. Pages 507-511 *in*. International Society for Horticultural Science (ISHS), Leuven, Belgium.

Peccoud, J., G. Labonne, and N. Sauvion. 2013. Molecular test to assign individuals within the *Cacopsylla pruni* complex. PLOS ONE 8(8):e72454.

Pignatta, D., C. P. Pollini, L. Giunchedi, C. Ratti, N. Reggiani, F. Forno, L. Mattedi, M. Gobber, P. Miorelli, and E. Ropelato. 2008. A real-time PCR assay for the detection of European stone fruit yellows phytoplasma (ESFYP) in plant propagation material. Acta Horticulturae 781:499.

Poggi Pollini, C., R. Bissani, L. Giunchedi, and E. Vindimian. 1995. Occurrence of Phytoplasma infection in European plums (*Prunus domestica*). Journal of Phytopathology 143(11-12):701-703.

Poggi Pollini, C., R. Bissani, G. Mordenti, L. Giunchedi, P. Cravedi, and R. Nicoli Aldini. 1996. Reperimento di fitoplasmi in cicadellidi mediante la tecnica della nested-PCR. Abstract Convegno SIPaV, Udine C 80.

Poggi Pollini, C., L. Giunchedi, and R. Bissani. 1997. Immunoenzymatic detection of PCR products for the identification of phytoplasmas in plants. Journal of Phytopathology 145(8-9):371-374.

Polak, J., J. Salava, M. Bryxiova, and J. Svoboda. 2007. Problems in detection of European stone fruit yellows phytoplasma in apricot trees in the Czech Republic. Bulletin of Insectology 60(2):261.

Quaglino, F., Y. Zhao, P. Casati, D. Bulgari, P. A. Bianco, W. Wei, and R. E. Davis. 2013. '*Candidatus* Phytoplasma solani', a novel taxon associated with stolbur- and bois noir-related diseases of plants. International Journal of Systematic and Evolutionary Microbiology 63(Pt_8):2879-2894.

Ramel, M., and P. Gugerli. 2003. Epidemiological survey of European stone fruit yellows phytoplasma in two orchards in western Switzerland. Pages 459-463 *in*

XIX International Symposium on Virus and Virus-like Diseases of Temperate Fruit Crops-Fruit Tree Diseases 657.
Riedle-Bauer, M., K. Bachinger, J. Stradinger, M. Emberger, J. Mörtel, and H. Sára. 2012. Transmission of European stone fruit yellows phytoplasma ('Candidatus Phytoplasma prunorum') during the propagation process. Mitteilungen Klosterneuburg 62(4):177-181.
Riedle-Bauer, M., C. Paleskic, J. Schwanzer, M. Kolber, K. Bachinger, L. Antonielli, and a. et. 2019. Epidemiological and molecular study on '*Candidatus* Phytoplasma prunorum' in Austria and Hungary. Annals of Applied Biology 175:400-414.
Sabaté, J., A. Laviña, and A. Batlle. 2016. Incidence and distribution of '*Candidatus* Phytoplasma prunorum' and its vector *Cacopsylla pruni* in Spain: an approach to the epidemiology of the disease and the role of wild *Prunus*. Plant Pathology 65:837-846.
Sánchez-Capuchino, J. A., G. Llácer, R. Casanova, J. B. Forner, and R. Bono. 1976. Epidemiological studies on fruit tree mycoplasma diseases in the eastern region of Spain. Pages 129-136 *in*. International Society for Horticultural Science (ISHS), Leuven, Belgium.
Sauvion, N., J. Peccoud, C. Meynard, and D. Ouvrard. 2021. Occurrence data for the two cryptic species of *Cacopsylla pruni* (Hemiptera: Psylloidea). ARPHA Preprints https://doi.org/10.3897/arphapreprints.e68864.
Seemuller, E., M. Garnier, and B. Schneider. 2002. Mycoplasmas of Plants and Insects. Pages 91-115 *in* S. Raxin and R. Herrmann, (eds.). Molecular Biology and Pathogenicity of Mycoplasmas. Kluwer Academic/Plenum Publishers, New York.
Seemüller, E., and B. Schneider. 2004. '*Candidatus* Phytoplasma mali', '*Candidatus* Phytoplasma pyri' and '*Candidatus* Phytoplasma prunorum', the causal agents of apple proliferation, pear decline and European stone fruit yellows, respectively. International Journal of Systematic and Evolutionary Microbiology 54(4):1217-1226.
Sertkaya, G., M. Martini, P. Ermacora, R. Musetti, and R. Osler. 2005. Detection and characterization of phytoplasmas in diseased stone fruits and pear by PCR-RFLP analysis in Turkey. Phytoparasitica 33(4):380-390.
Steffek, R., S. Follak, N. Sauvion, G. Labonne, and A. MacLeod. 2012. Distribution of '*Candidatus* Phytoplasma prunorum' and its vector *Cacopsylla pruni* in European fruit-growing areas: a review. EPPO Bulletin 42(2):191-202.
Takeuchi, Y., G. Fowler, and A. S. Joseph. 2018. SAFARIS: Global Plant Hardiness Zone Development. North Carolina State University, Center for Integrated Pest Management; United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Science and Technology, Plant Epidemiology and Risk Analysis Laboratory, Raleigh, NC. 6p.
Thébaud, G., M. Yvon, R. Alary, N. Sauvion, and G. Labonne. 2009. Efficient transmission of *'Candidatus* Phytoplasma prunorum' is delayed by eight months due to a long latency in its host-alternating vector. Phytopathology 99:265-273.
Topchiiska, M., C. Marcone, and E. Seemüller. 2000. Detection of pear decline and European stone fruit yellows in Bulgaria/Nachweis des Birnenverfalls und der europäischen Steinobstvergilbung in Bulgarien. Zeitschrift für

Pflanzenkrankheiten und Pflanzenschutz/Journal of Plant Diseases and Protection:658-663.
Trandafirescu, M., C. Plopa, and I. Trandafirescu. 2011. Symptomatological detection and biochemical changes of the trees infected by apricot chlorotic leafroll phytoplasma. Bulletin of Insectology 64 (Supplement):S165-S166.
Trivellone, V., and C. H. Dietrich. 2020. Evolutionary diversification in insect vector–phytoplasma–plant associations. Annals of the Entomological Society of America 114(2):137-150.
Ulubaş Serçe, Ç, M. Gazel, K. Çaglayan, M. Baş, and L. Son. 2006. Phytoplasma disease of fruit trees in germplasm and commercial orchards in Turkey. Journal of Plant Pathology 88(2):179-185.
USDA. 2021. Plants for Planting Manual (eds.)
Valasevich, N., and B. Schneider. 2016. Detection, identification and molecular diversity of '*Candidatus* Phytoplasma prunorum' in Belarus. Journal of Plant Pathology 98(3):625-629.
Varga, K., M. Kölber, M. Martini, M. Pondrelli, I. Ember, G. Tökés, J. Lázár, J. Mikulás, E. Papp, and G. Szendrey. 2000. Phytoplasma identification in Hungarian grapevines by two nested-PCR systems. Pages 12-17 *in* Extended abstracts of XIIIth meeting of the International Council for the Study of viruses and virus-like diseases of the grapevine (ICVG). Adelaide, Australia.
Verbeek, I. M. 2008. Vectors of phytoplasma diseases in Dutch orchards. Dutch Research Database (NOD). http://www.onderzoekinformatie.nl/en/oi/nod/onderzoek/OND1331163/.
Weintraub, P. G., and P. Jones. 2009. Phytoplasmas: Genomes, Plant Hosts And Vectors. CAB International 2010.

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