EPPO Datasheet: *'Candidatus Phytoplasma mali'*

Last updated: 2024-06-12

IDENTITY

Preferred name: *'Candidatus Phytoplasma mali'*
Authority: Seemüller & Schneider
Taxonomic position: Bacteria: Tenericutes: Mollicutes: Acholeplasmatales: Acholeplasmataceae
Other scientific names: *Apple proliferation phytoplasma*, *Apple witches' broom phytoplasma*, *Phytoplasma mali* Seemüller & Schneider
Common names: AP, proliferation of apple, witches' broom of apple
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EPPO Categorization: A2 list
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EU Categorization: RNQP ((EU) 2019/2072 Annex IV)
EPPO Code: PHYPMA



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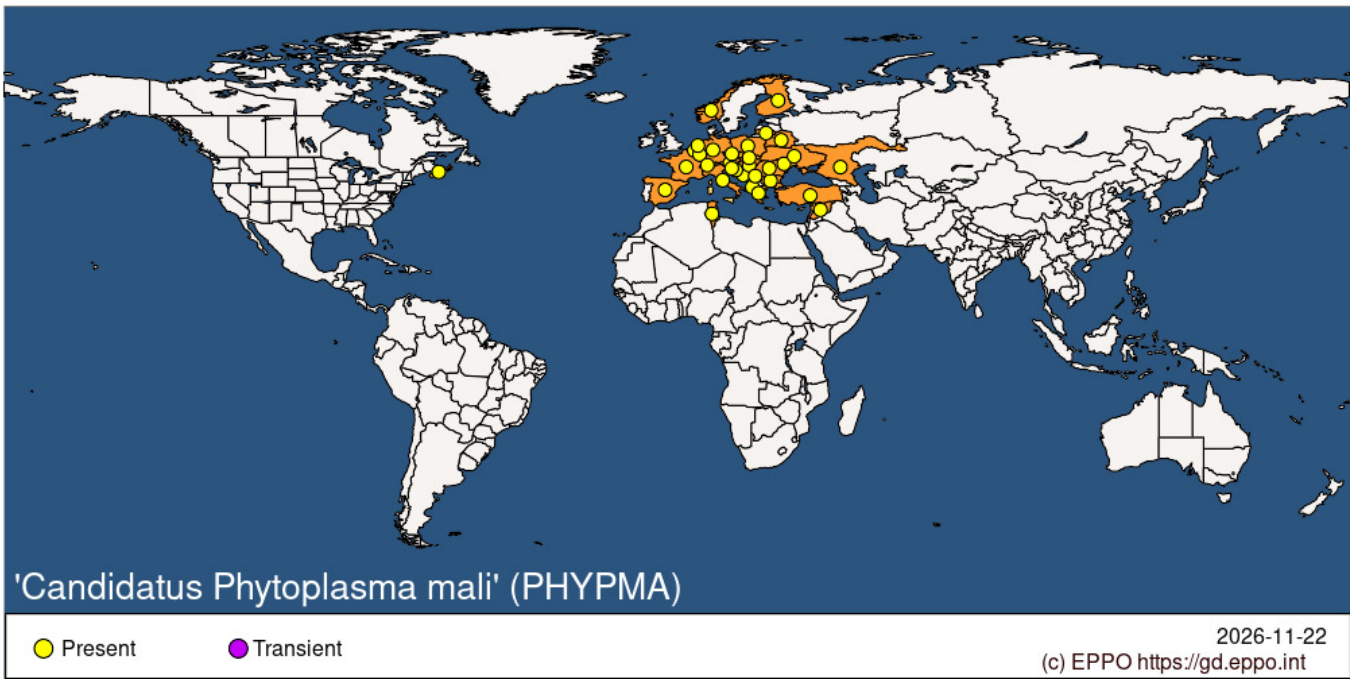
HOSTS

Apple trees are the main host. Cultivars vary in reaction but most, including seedlings, appear to be susceptible. The most sensitive cultivars include Belle de Boskoop, Gravenstein, Starking, Golden Delicious and Winter Banana. Some cultivars are mentioned as relatively tolerant to '*Ca*. P. mali' infection (Seemüller *et al*., 2011). However, tolerance evaluation of these cultivars is rather based on empirical field observations assessing symptom occurrence than on a screening through targeted infection trials (Janik *et al*., 2020).

Host list: *Carpinus betulus*, *Convolvulus arvensis*, *Corylus avellana*, *Crataegus monogyna*, *Dahlia hybrids*, *Forsythia suspensa*, *Lilium hybrids*, *Malus baccata*, *Malus domestica*, *Malus floribunda*, *Malus fusca*, *Malus halliana*, *Malus hupehensis*, *Malus kansuensis*, *Malus prunifolia*, *Malus sargentii*, *Malus spectabilis*, *Malus sylvestris* , *Malus toringoides*, *Malus x adstringens*, *Malus x atrosanguinea*, *Malus x magdeburgensis*, *Malus x micromalus*, *Malus x moerlandsii*, *Malus x purpurea*, *Malus x scheideckeri*, *Malus x soulardii*, *Malus x zumi*, *Prunus armeniaca*, *Prunus avium*, *Prunus domestica*, *Prunus persica*, *Prunus salicina*, *Punica granatum*, *Pyrus communis*, *Pyrus pyrifolia*, *Quercus robur*, *Quercus rubra*, *Ribes sp.*, *Spiraea x vanhouttei*, *Viburnum lantana*, *Vitis vinifera*

GEOGRAPHICAL DISTRIBUTION

'*Ca*. P. mali' has been reported from the EPPO region, Africa (Tunisia), Asia (Syria) and North America (Canada - Nova Scotia).



EPPO Region: Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Finland, France (mainland), Germany, Greece (mainland), Hungary, Italy (mainland), Lithuania, Luxembourg, Moldova, Republic of, Netherlands, Norway, Poland, Romania, Russian Federation (Southern Russia), Serbia, Slovakia, Slovenia, Spain (mainland), Switzerland, Tunisia, Türkiye, Ukraine
Africa: Tunisia
Asia: Syrian Arab Republic
North America: Canada (Nova Scotia)

BIOLOGY

'*Ca*. P. mali' is a plant pathogen that resides in the phloem and its distribution in the tree is not constant over the year. It appears to be localized mainly in suckers and terminal shoots, where it has been observed in the phloem of leaf petioles, midribs and stipules (Fránová, 2005). In winter the content of phytoplasmas declines due to sieve tube degeneration. They also concentrate more in the roots in winter but, during April to May, the pathogen reinvades the stem from the roots and reach a peak level of infection in late summer or early autumn (Seemüller *et al.*, 1984). The distribution pattern of the phytoplasmas in the tree is also dependent on temperature. In France, phytoplasmas could be found throughout the trees at temperatures of 21-24°C, causing symptoms; at 29-32°C symptoms were inhibited and phytoplasmas were found only in the roots, but reinvaded the stems when plantlets were stored at 21-24°C (Ducrocquet *et al.*, 1986).

When a tree is inoculated with an infected bud the first symptoms appear the following year, mostly on the inoculated branches. When carried in the rootstock, the causal agent produces symptoms on the first growth of the scion.

Psyllids *Cacopsylla picta* (syn. *C. costalis*) and *Cacopsylla melanoneura* (Hemiptera: Sternorryncha: Psyllidae), and the leafhopper *Fieberiella florii* (Hemiptera: Auchenorrhyncha: Cicadellidae) have been shown to be '*Ca*. P. mali' vectors (Janik *et al*., 2020). They transmit '*Ca*. P. mali' in a persistent-propagative manner, which means that the pathogen can multiply in insects and that the insect remains inoculative for life (Weintraub & Beanland, 2006). Mittelberger *et al*., (2017) showed that *C. picta* vertically transmits '*Ca*. P. mali' from infected mothers to their offspring (transovarial transmission).

Although the spatial distribution, infection rate and transmission capacity of *C. picta* and *C. melanoneura* vary among geographical areas, these psyllids are more efficient vectors than the leafhopper, *F. florii*. Studies have shown that *F. florii* is relatively inefficient, due to its low transmission rate and low incidence in apple orchards (Tedeschi & Alma, 2006). Both adults and nymphs of *C. picta* and *C. melanoneura* transmit '*Ca*. P. mali'.

C. melanoneura is oligophagous, mainly feeding on *Malus* spp. and *Crataegus* spp., and occasionally on *Pyrus* spp.; whereas *C. picta* is monophagous, feeding only on *Malus* spp. *C. picta* is distributed across Europe and Asia Minor whereas *C. melanoneura* is widespread across the Palearctic region. In Northeastern Italy, Germany and East European countries *C. picta* and *C. melanoneura* occur together, but *C. picta* plays a major role as a vector (Oppedisano *et al*., 2019).

Both *Cacopsylla* species have one generation per year and overwinter as adults (Lauterer, 1999; Jarausch *et al*., 2011; Tedeschi *et al*., 2012) on shelter plants, mainly conifers (?ermák & Lauterer, 2008). At the end of winter, adults (remigrants) return to their rosaceous hosts for mating and oviposition. In Italy, *C. melanoneura* migrates from overwintering sites to orchards from the end of January to mid-March, whereas *C. picta* migrates later, from the end of March to April. Nymphal development then takes four to five weeks, and the newly hatched adults (emigrants) remain in the orchards for about two weeks before progressively migrating to their overwintering sites - until June for *C. melanoneura* and July for *C. picta* (Mattedi *et al*., 2008). *C. picta* adults are already highly infective when migrating from shelter plants to apple trees (Carraro *et al*. (2008) and they remain infective throughout the entire period spent in apple orchards (Jarausch *et al.*, 2011).

DETECTION AND IDENTIFICATION

Symptoms

On trees

Affected trees lack vigour, shoots are thin and the bark, which is sometimes fluted lengthwise, has a reddish-brown colour. Necrotic areas appear on the bark and some branches may wither. Diseased trees may die but, in mild infections, they may recover after the shock symptoms of the first 2-3 years and, subsequently, produce normal fruits again, especially if adequately fertilized.

On buds

Late growth of terminal buds in the autumn is usually the first noticeable symptom. A rosette of terminal leaves, which often becomes infected with powdery mildew, sometimes develops late in the season in place of the normal dormant bud. However, a more reliable symptom of '*Ca*. P. mali' infection is the premature development of axillary buds, during the first 2 or 3 years following infection, which gives rise to secondary shoots forming witches' brooms near the apex of the main shoot. In healthy trees, on the other hand, lateral shoots arise near the base of the shoots. The angle between the secondary shoots and the main shoot is markedly narrower on infected trees. Witches' brooms generally appear successively on various parts of the tree, or all at once over the whole tree, rather than repeatedly on the same branch.

On leaves

On infected trees, leaves appear earlier than normal and are finely and irregularly serrated and smaller. In many cases, especially with trees on calcareous soils, there is a chlorosis and reddening of the leaves. Early defoliation often occurs. It should be noted that chlorosis and reddening of leaves may be caused by agents other than '*Ca*. P. mali'; diagnosis should not, therefore, be based on this symptom alone.

On stipules

Stipules are abnormally long, and there may be up to four per leaf. Petioles are rather short.

On flowers

Flowering is delayed, sometimes until late summer or autumn, but most of the blossoms of infected trees are normal. A few phylloid flowers have been observed on cv. Cox's Orange; the stamens were converted to petals, some of the petals to leaves and the calyx lobes were enlarged and dentated.

On fruit

Depending on soil quality, fruit are markedly reduced in size, sometimes being only 25% of the weight of healthy fruit. In addition, the flavour is poor, with both sugar and acidity being reduced. The peduncles are longer and thinner and both the calyx end and peduncular cavities are shallower and broader, thus giving the fruit a flattened appearance. Seeds and seed cavities are smaller.

For more information, see EPPO (2020), Janik *et al.* (2020).

Detection and inspection methods

Different molecular methods based on the detection of '*Ca*. P. mali' specific DNA are available. The tests recommended for diagnostics are a conventional PCR test with primers fU5/rU3 (Lorenz *et al*., 1995), a LAMP test (De Jonghe *et al*., 2017) and two real-time PCR tests developed by Christensen *et al*. (2004) and Hodgetts *et al*. (2009).

Diagnostic tests based on biological assays in which suspicious infected material is grafted to woody indicator plants, microscopic examination (DAPI), serological assays using specific antibodies against '*Ca.* P. mali', e.g. enzyme-linked immunosorbent assays (ELISA) or immunofluorescence detection were developed and used in past decades. However, these techniques are often work-intense, time consuming, have a low sensitivity or are prone to generate false-negative results (Janik *et al*., 2020).

More details on the inspection, detection and identification of '*Ca*. P. mali' can be found in EPPO Standards (1999, 2020, 2021).

PATHWAYS FOR MOVEMENT

Natural movement of insect vectors plays a significant role in spreading the phytoplasma over short distances, from tree to tree, within the same orchard or between adjacent orchards. Transmission by root fusion may occur. There is no seed or pollen transmission (Seidl & Komarkova, 1974). By dodder (*Cuscuta* sp.) or by grafting '*Ca*. P. mali' can be transmitted from apple to apple, to periwinkle (*Catharanthus roseus*) and to other experimental hosts. So far, there is no evidence of an involvement of wild plants other than hawthorn (*Crataegus* sp.) as reservoirs for the pathogen in the epidemic cycle (Janik *et al*., 2020). Over longer distances, '*Ca*. P. mali' is mainly disseminated by movements of infected trees, scions and rootstock material of apple. Infected symptomless trees may yield a high proportion of apparently healthy but infected buds.

PEST SIGNIFICANCE

Economic impact

This is one of the most important phytoplasma diseases of apple, affecting almost all cultivars, reducing size (by about 50%), weight (by 63-74%) and quality of fruit, as well as reducing tree vigour and increasing susceptibility to powdery mildew (*Podosphaera leucotricha*). Yield reduction caused by apple proliferation disease in Italy has led to an economic loss of about 100 million Euros in 2001 (Strauss, 2009).

Control

As there are no curative treatments for the disease, a combination of different preventive strategies, such as vector control by means of multiple insecticide treatments, eradication of infected trees and use of certified non-infected planting material, are currently the only measures to prevent '*Ca*. P. mali' spread.

Various methods of vector monitoring, such as visual inspection, beating tray, sticky traps (Jarausch & Torres, 2014) or sweep-net can be used by apple growers to detect *C. picta* and *C. melanoneura* outbreaks and ensure their

effective control by application of insecticides (Janik *et al*., 2020).

Processed kaolin was shown to be an alternative to broad-spectrum insecticides against *C. melanoneura* in organic farming. It acts by creating a film that hinders insects from feeding or moving onto the plants, and also prevents the transmission of plant pathogens by insect vectors (Tedeschi *et al*., 2007). Late winter spray with kaolin reduced the number of laid eggs and consequently of nymphs (Janik *et al.*, 2020).

The use of '*Ca*. P. mali' resistant rootstocks would be the most sustainable solution. Extensive studies done by Seemüller and co-workers since 1992 led to the development of promising resistant *Malus sieboldii* rootstocks (Seemüller *et al*., 2018). However, despite all efforts no apple variety was found that confers full resistance (i.e. that it cannot be infected) against '*Ca*. P. mali' (Janik *et al*., 2020).

Phytosanitary risk

Apple trees are among the most economically important fruit crops in the EPPO region. Further spread of the disease could lead to considerable yield losses throughout the European and Mediterranean apple cultivation areas.

PHYTOSANITARY MEASURES

Plants for planting of *Malus* should come from a place of production found to be free from '*Ca*. P. mali' during the previous growing season. Guidance on how to inspect *Malus* varieties and rootstocks at places which are producing plants for planting is given in the EPPO Standard PM 3/76 (EPPO, 2021). From countries where the disease occurs, the plants must additionally be no further than the second generation from the mother plant and must be tested by an EPPO-approved method (EPPO, 2020). The EPPO certification scheme for *Malus, Pyrus* and *Cydonia* (EPPO, 1999) covers '*Ca*. P. mali' and should give a high security for phytoplasma-free planting material.

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CABI and EFSA resources used when preparing this datasheet

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Datasheet history

This datasheet was first published in the EPPO Bulletin in 1978 and revised in the two editions of 'Quarantine Pests for Europe' in 1992 and 1997, as well as in 2024. It is now maintained in an electronic format in the EPPO Global Database. The sections on 'Identity', 'Hosts', and 'Geographical distribution' are automatically updated from the database. For other sections, the date of last revision is indicated on the right.

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