Prepared by CABI and EPPO for the EU under Contract 90/399003

Data Sheets on Quarantine Pests

Elm phloem necrosis phytoplasma and its vector *Scaphoideus luteolus*

IDENTITY

- **Elm phloem necrosis phytoplasma**
  Name: Elm phloem necrosis phytoplasma
  Taxonomic position: Bacteria: Tenericutes: Mollicutes: Phytoplasmas
  Common names: Elm phloem necrosis, elm yellows (especially in USA) (English)
  Nécrose du liber de l'orme (French)
  Phloemnekrose der Ulme (German)
  Notes on taxonomy and nomenclature: Sinclair (1981) gives the name elm yellows phytoplasma to this organism on the basis that the phloem necrosis symptom is a special case in the highly susceptible *Ulmus americana*. Yellows is the more characteristic symptom. Use of the name elm yellows introduces a confusion, for phytoplasmas causing yellows in *Ulmus* have been described in Europe (at least France and Italy) (Conti *et al*., 1987). Until the opposite is proved, these European elm yellows phytoplasmas are presumed to be distinct from elm phloem necrosis phytoplasma (the North American elm yellows phytoplasma).
  EPPO computer code: EMPNXX
  EPPO A1 list: No. 26
  EU Annex designation: I/A1
- ***Scaphoideus luteolus***
  Name: *Scaphoideus luteolus* van Duzee
  Taxonomic position: Insecta: Hemiptera: Homoptera: Cicadellidae
  Common names: White-banded elm leafhopper (English)
  Cigale de l'orme (French)
  Gelbliche Kahnzikade (German)
  Bayer computer code: SCAPLU
  EU Annex designation: I/A1

HOSTS

- **Elm phloem necrosis phytoplasma**
  The only known hosts are elms (*Ulmus* spp.) including the American species *U. americana*, *U. rubra*, *U. alata*, *U. serotina* and *U. crassifolia*. The natural hybrid *U. pumila* x *rubra* has been found infected in New York State, USA. Old World *Ulmus* spp. grown in North America have not been found to be naturally infected by elm phloem necrosis phytoplasma (Sinclair, 1981). Experimentally, however, the phytoplasma has been graft-transmitted to the Old World species *U. minor*, *U. laevis* and *U. parvifolia* (but not *U. glabra* or *U. pumila*) and caused witches' broom symptoms in them, rather than phloem necrosis or yellows. The only non-elm suscept to which the phytoplasma has been experimentally transmitted is *Catharanthus roseus* and this was effected using *Cuscuta epithymum*. The

reciprocal transfer has not, however, been accomplished. Other hosts could harbour latent infections, but this requires further investigation.

- ***Scaphoideus luteolus***
  Ulmus spp. are the only hosts, especially *U. americana*, *U. rubra* and *U. alata*. It is not clear to what extent *S. luteolus* feeds on Old World elms planted in North America. Sinclair (1981) suggests that they may escape infection by the phytoplasma because of the food preferences of the vector.

GEOGRAPHICAL DISTRIBUTION

- **Elm phloem necrosis phytoplasma**
  EPPO region: Absent.
  North America: Canada (Niagara peninsula in Ontario, since 1984; Matteoni & Sinclair, 1989), USA approximately from latitudes 32 to 46° N and longitudes 71 to 97° W, including Alabama, Arkansas, Georgia, Iowa, Illinois, Indiana, Kansas, Kentucky, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, Tennessee, West Virginia. Recorded since 1882 in Ohio. Recently found significantly further west in North Dakota (Stack & Freeman, 1988).
  EU: Absent.
  Distribution map: See CMI (1975, No. 107).
- ***Scaphoideus luteolus***
  EPPO region: Absent.
  North America: USA (throughout known range of the elm phloem necrosis phytoplasma and beyond in northern areas from Minnesota to Maine).
  EU: Absent.

BIOLOGY

- **Elm phloem necrosis phytoplasma**
  Besides its transmission by *S. luteolus* (see below), the phytoplasma may also be transmitted by root grafts and bark patch grafts; mechanical inoculations have been unsuccessful. In the USA, epidemics occur where average annual minimum temperatures are over -23°C, but the disease has been found in areas where average temperatures fall below -26°C. Although spectacularly destructive, epidemics are usually localized, and spread into contiguous localities is neither quick nor certain. In New York State (USA), observations suggest an annual rate of spread of 5-8 km in some places and apparent disappearance in others. The disease may persist at a low level for many years between epidemics.

  Within the tree, the phytoplasma is found only in the phloem sieve tubes, where it induces callose deposition and cell collapse. It is thought to overwinter in the few uncollapsed sieve elements in the roots and then move to the upper parts of the tree after new functional phloem has been produced in the spring (Braun & Sinclair, 1976).

  For more information, see Sinclair (1981).
- ***Scaphoideus luteolus***
  S. luteolus is the only confirmed vector (Baker, 1948; 1949) but there may be others (over 100 species of leafhoppers and planthoppers, in genera that include phytoplasma vectors, have been found and probably feed on elms in North America; *S. luteolus* is rare in some areas where the disease occurs). In Ohio, *S. luteolus* overwinters as eggs in bark of small branches of elms. There is an extended hatching period and five nymphal instars develop over 36-42 days. Adults are present from early July until frosts, and are the only winged stage. Both adults and nymphs can acquire and transmit the phytoplasma; there is an

incubation period of about 3 weeks, and thereafter the insect is infective for life (Sinclair *et al*., 1976). *S. luteolus* is the main member of its genus found on elms but other species also live on elms (Barnett, 1977).

DETECTION AND IDENTIFICATION

Symptoms

- **Elm phloem necrosis phytoplasma**

The fibrous roots and then the larger roots die; hyperplasia and hypertrophy may be evident. This is in fact the first symptom but is rarely detected until aerial symptoms are apparent. External symptoms of phloem necrosis are variable. The first foliar symptoms usually develop between mid-July and mid-September in the northern USA and include yellowing, epinasty (drooping or downward bending of turgid leaves) and premature casting. Usually, all branches on a tree show symptoms at once. Sometimes, however, symptoms develop in just one branch system of a tree, while other parts remain normal for a time. Bright-yellow leaves may occur together with green ones on a single small branch, but more often all leaves on a branch assume the same yellowish-green to yellow colour.

Late in the growing season, the leaves on infected trees appear prematurely senescent. The yellowing and senescence are indistinguishable from symptoms caused during drought periods by water stress in trees growing on inadequate sites, such as shallow soils overlying rock ledges. Infected trees showing these late-season symptoms may fail to produce leaves the next spring or may begin growth and then die.

In early spring, the first external symptoms in some trees are their failure to produce leaves, or the production of dwarfed leaves which later wilt or turn yellow and fall. In late spring, after leaves develop normally, rapid wilting and death may occur. Shrivelled brown leaves may adhere to these rapidly killed trees for several weeks. Wilting of infected trees is most common during mid-summer, but can occur at any time during the growing season. Trees noticeably affected in June die the same summer although, on the whole, trees die in the year following attack.

The inner phloem of lower trunk and roots develops a butterscotch colour, sometimes even before foliage symptoms appear. In large stems, the discoloration tends to occur in vertical bands with diffuse margins, associated with the positions of specific buttress roots. The cambial region and the surface of the wood may also show discoloration but the abnormal colour does not extend more than about 1 mm into the wood. If very dark discoloration of the outer wood is seen, in addition to phloem discoloration, this may indicate that the tree has been attacked by both *Ceratocystis ulmi* (Dutch elm disease; OEPP/EPPO, 1982) and the phytoplasma. Oxidative browning of freshly exposed inner phloem is much more rapid in infected than in healthy trees.

Following artificial inoculation, symptoms take 3-12 months to develop. Tolerant *Ulmus* spp. produce witches' brooms. For more information on symptomatology, see Swingle (1942), Sinclair (1972), Sinclair & Filer (1974), Sinclair (1981).

- ***Scaphoideus luteolus***

S. luteolus feeds on the leaf veins, but causes no characteristic symptoms.

Morphology

- **Elm phloem necrosis phytoplasma**

The discovery of phytoplasmas in phloem sieve tubes in roots and stems (Wilson *et al.*, 1972) first indicated the aetiology of elm phloem necrosis.

- ***Scaphoideus luteolus***

Adults 4-4.5 mm (male) or 4.8-5.2 mm (female), with roof-like brownish wings and long, thin antennae. Head triangular, flat above and yellowish. Thorax shield yellowish and half-

moon-shaped. This description applies to other species of the genus, and positive identification requires dissection of the genital tract (Barnett, 1977).

The nymphs resemble the adults in form. The early instars are whitish, but in the 3rd instar the nymphs become dark-brown while the dorsal part of the two anterior abdominal segments remains white. This white band is characteristic of the 3rd to 5th instars of *S. luteolus*, but disappears in the adult.

Detection and inspection methods

- **Elm phloem necrosis phytoplasma**

In *U. americana*, *U. alata*, *U. crassifolia* or *U. serotina* (Sinclair & Filer, 1974; Braun & Sinclair, 1976), when inner bark, in particular of the lower trunk and buttress root area, of an infected tree is stripped and promptly put into a capped bottle for a few minutes, a wintergreen odour (methyl salicylate) can be detected. *Ceratocystis ulmi* alone can also cause yellow discoloration of the inner phloem surface, but no wintergreen odour comes from such discoloured phloem.

MEANS OF MOVEMENT AND DISPERSAL

Transmission by the vector will occur only locally, and the disease has a restricted distribution within the USA. In international trade, infected planting material of elms could carry the disease, or possibly also infective vectors. The vector itself would most probably be carried as eggs in the bark of elm plants (though these would not be infective).

PEST SIGNIFICANCE

Economic impact

- **Elm phloem necrosis phytoplasma**

Phloem necrosis has killed large numbers of elm trees in the USA, from the Great Plains eastward to New York and south to Mississippi (Sinclair, 1972; Carter & Carter, 1974). The incidence of phloem necrosis results in an increase in the occurrence of *Ceratocystis ulmi* (Dutch elm disease), since vectors of the latter colonize dying trees affected by the former, although in some central states phloem necrosis has killed more trees than *C. ulmi*. A number of devastating epidemics have developed in the midwest since the 1940s. An epidemic occurred in northern Mississippi in 1970 and another in central New York in 1971-1975. A 10-year intensive study of an elm population in New York State (Lanier *et al.*, 1988) shows how serious elm phloem necrosis can be, and how it is spreading south-eastwards in the USA.

- ***Scaphoideus luteolus***

S. luteolus is of no importance as a pest in its own right; its only significance is as an phytoplasma vector.

Control

At present, there is no proven practical method for prevention or cure. Control of the vector is quite impractical.

Phytosanitary risk

Elm phloem necrosis phytoplasma is an EPPO A1 quarantine pest (OEPP/EPPO, 1979) and is also of quarantine significance for IAPSC. The vector is of no quarantine significance in its own right. It appears that Asian and European elms are moderately or highly resistant to the phloem necrosis agent. It has been suggested that the phytoplasma is an elm pathogen native to and unimportant in Europe or Asia, which was introduced into the USA during the 1800s in infected seedlings before they developed symptoms. As mentioned under Notes on taxonomy and nomenclature, elms in Europe are affected by minor yellows (Conti

et al., 1987) and witches' broom diseases (Pisi *et al.*, 1981) caused by phytoplasmas and probably transmitted by leafhoppers. When it becomes possible to test for serological cross reactions between these phytoplasmas and North American elm phloem necrosis phytoplasma, these questions can be resolved; for the time being, the suggestion that the latter already occurs in the EPPO region remains unsubstantiated, and the pathogen is a threat to European elms, already hard hit by the aggressive strains of Dutch elm disease. Further research is needed; it could lead to the conclusion that elm phloem necrosis phytoplasma presents no risk to Old World *Ulmus* spp.

PHYTOSANITARY MEASURES

EPPO recommends prohibition of import of elm plants from infested countries (OEPP/EPPO, 1990), to protect against both phytoplasma and vector. If material is imported with a permit, it would be advisable to fumigate it, or treat it with insecticide, to destroy eggs and other stages of the vector. An adequate quarantine period would be the only safeguard against infection of the elm material with the phytoplasma.

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