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Data Sheets on Quarantine Pests

Ceratocystis fagacearum and its vectors

IDENTITY

- ***Ceratocystis fagacearum***
  Name: *Ceratocystis fagacearum* (Bretz) Hunt
  Synonyms: *Chalara quercina* Henry
  Anamorph: *Endoconidiophora fagacearum* Bretz
  Taxonomic position: Fungi: Ascomycetes: Ophiostomatales
  Common names: Oak wilt (English)
  Flétrissement américain du chêne (French)
  Eichenwelk (German)
  Bayer computer code: CERAFA
  EPPO A1 list: No. 6
  EU Annex designation: I/A1
- ***Pseudopityophthorus minutissimus***
  Name: *Pseudopityophthorus minutissimus* (Zimmermann)
  Synonyms: *Crypturgus minutissimus* Zimmermann
  Taxonomic position: Insecta: Coleoptera: Scolytidae
  Common names: Oak bark beetle (English)
  Bayer computer code: PSDPMI
  EU Annex designation: I/A1
- ***Pseudopityophthorus pruinosus***
  Name: *Pseudopityophthorus pruinosus* (Eichhoff)
  Synonyms: *Pityophthorus pruinosus* Eichhoff
  Pityophthorus tomentosus Eichhoff
  Pityophthorus querciperda Schwarz
  Pseudopityophthorus pulvereus Blackman
  Pseudopityophthorus tropicalis Wood
  Pseudopityophthorus convexus Bright
  Taxonomic position: Insecta: Coleoptera: Scolytidae
  Common names: Oak bark beetle (English)
  Bayer computer code: PSDPPR
  EU Annex designation: I/A1

HOSTS

C. fagacearum attacks *Quercus* spp. and no North American oak is known to be immune. Red oaks (subgenus *Erythrobalanus*) usually die within a few weeks of infection. American white oaks (subgenus *Lepidobalanus*) are more resistant and may recover from the disease. If they die, it is usually over a period of several years. In an attempt to assess the susceptibility of European oaks, hundreds of European white oaks were inoculated in West Virginia and South Carolina (Pinon *et al*., 1997). All individual oaks inoculated appeared susceptible, regardless of the species (*Q. robur*, *Q. petraea*, *Q. pubescens*) and died within

the year following inoculation. Infection and subsequent death were equally observed after branch or stem inoculations. No significant variability was found between the provenances of these species collected from various European countries. Root graft transmission also became obvious within a few weeks and led to the death of contaminated trees during the following year (Pinon *et al*., 1997 & 2003).

Pseudopityophthorus spp. are mainly found on *Quercus* although other hardwood hosts have been recorded. In Wisconsin (USA), *P. minutissimus* was found by McMullen *et al*. (1955) to be common in red oaks but absent from white oaks.

GEOGRAPHICAL DISTRIBUTION

- ***Ceratocystis fagacearum***

C. fagacearum is indigenous to North America and has not spread to other continents.
EPPO region: Absent.
North America: USA (indigenous in eastern and mid-west states, being recorded from Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia, Wisconsin). The area is delimited by a line from central Pennsylvania to Georgia, westward through Tennessee and Arkansas to Texas, then north to Minnesota and eastwards through Wisconsin and Michigan to Pennsylvania. There is no evidence for a significant increase in the area of distribution in recent decades and unaffected oak populations are to be found north-east and south of its boundaries.
EU: Absent.
Distribution map: See IMI (1993, No. 254), Gibbs & French (1980), Appel *et al.* (1985), Juzwik *et al*. (2011).

- ***Pseudopityophthorus* spp.**

EPPO region: Absent.
North America: Canada (*P. minutissimus*, southern Ontario and Quebec), Mexico (*P. pruinosus*), USA (*P. minutissimus*, Minnesota and Maine to Louisiana and Florida; *P. pruinosus*, Michigan and New York to Texas and Florida).
Central America and Caribbean: Guatemala (*P. pruinosus*), Honduras (*P. pruinosus*).
EU: Absent.

BIOLOGY

- ***Ceratocystis fagacearum***

C. fagacearum is a classic vascular wilt pathogen, with the fungus confined to the vessels of the outermost xylem ring until the tree becomes moribund. In a diseased red oak, passive movement of spores within the transpiration stream usually results in the fungus being transported to all parts of the tree. When a red oak dies, growth of the fungus out into the inner bark can lead to the production of sporulating mats, although this may be prevented by high summer temperatures and competition from other fungi. Mats produce endoconidiophores initially, and then perithecia, if fertilization is effected by the introduction on insects of the other mating type of the fungus. Antagonistic fungi hasten the degeneration of the mat and the pathogen usually disappears from the above-ground parts of a dead tree within a year of wilting. Survival in the root system may be more prolonged, especially if the roots are grafted to those of neighbouring trees.

In a diseased white oak, distribution of the fungus in xylem of the current annual ring is much more restricted than in red oaks. If the tree recovers, the infected ring will be buried

under new xylem and is most unlikely to constitute a significant source of inoculum. For a review of many aspects of disease biology, see Gibbs & French (1980). More recent studies include those of Juzwik *et al.* (1985) and Appel (1986).

In many parts of its range, the most important means of dispersal is through the transportation of spores of the fungus across root grafts as a result of the movement of water to transpiring healthy trees from non-transpiring diseased ones. In parts of the disease range, all the oaks are grafted together. Under these conditions disease centres can enlarge rapidly. Thus a radial rate of 7.5 m per year occurs in *Q. ellipsoidalis* in Minnesota and 11-16 m per year in *Q. fusiformis* in Texas (USA). Elsewhere functional grafts are much more infrequent and underground spread is slower and more erratic.

Above-ground spread is a relatively rare event. In the north of the disease range, it occurs principally through the activities of sap-feeding nitidulid beetles (e.g. *Colopterus truncatus, Carpophilus sayi*) which disseminate spores from the sporulating mats to fresh wounds on healthy trees (Ambourn *et al*., 2005). In some areas further south, the oak bark beetles *Pseudopityophthorus minutissimus* and *P. pruinosus* (see below) are thought to be more important as vectors, chiefly because sporulating mats are rarely produced. However, in Texas, at the extreme south of the disease range, mats are commonly produced on *Q. texana* and nitidulids are considered important as vectors in this state (Appel *et al.*, 1987).

There are only a few instances where it is suspected that the movement of diseased materials by man has resulted in the appearance of a new disease outbreak. Nevertheless, knowledge that sporulating mats can be produced on logs from diseased trees has greatly influenced European attitudes towards the disease.

- ***Pseudopityophthorus* spp.**

Two generations of beetles occur per year through most of the oak wilt range. In states such as Ohio (USA), all stages successfully overwinter except the pupae. Further north in Wisconsin however, where only *P. minutissimus* is present, the larger larvae are the only winter-resistant stage. These emerge as adults in May. Young adult beetles commonly make deep feeding wounds in the twig crotches, leaf axils, bud axils and immature acorn axils of both red and white oaks. Fresh feeding wounds can be found from early spring onwards and it has been established that the wounds are capable of acting as infection courts when inoculated with the oak wilt fungus. The percentage of young adult beetles carrying the fungus is very variable. As many as 30% of beetles emerging from some trees with oak wilt can carry the fungus but a more typical figure is between 0.4 and 2.5%.

It also seems possible that parent beetles transmit the disease in spring. They may make a gallery system in a diseased tree, emerge to feed on twigs of healthy trees, and then breed again in a healthy tree.

DETECTION AND IDENTIFICATION

Symptoms

- ***Ceratocystis fagacearum***

On red oaks, from early May onwards, foliage on entire trees rapidly wilts and turns brown. Some of the dead leaves can persist on the trees for long periods. Occasionally individual leaves may become brown from the leaf apex, with the base of the leaf remaining green. Some diffuse staining may be observed in the outermost xylem ring. Within a few months of tree death, sporulating mats may form below the bark. These are characterized by a central "pressure cushion" surrounded by a greyish mat of mycelium and spore-bearing structures (endoconidiophores and perhaps perithecia). The mats have a strong fruity smell. In the evergreen *Quercus fusiformis*, wilting does not occur but the leaves show veinal necrosis and tip scorch (Appel, 1986).

On white oaks, the wilting and death of foliage often occurs only on a few branches. Quite pronounced xylem stain can usually be found in these branches. Sporulating mats are only rarely found.

- ***Pseudopityophthorus* spp.**
  The breeding galleries of oak bark beetles have an entrance gallery extending through the bark to the sapwood. The egg galleries are horizontal, i.e. across the grain, and extend on both sides of the entrance gallery for about 2-5 cm. Eggs are laid in niches along the galleries and the larval workings are longitudinal, following the grain. Galleries are normally found in stems or branches between 1 and 10 cm in diameter, although they can be found in stems of 40 cm diameter.

Morphology

- ***Ceratocystis fagacearum***
  Xylem chips taken from branches showing active disease symptoms should yield the fungus in culture. On malt agar the culture is greyish with a sweet fruity smell. Endoconidiophores and endospores are produced in culture, the latter with an angular growth habit. Perithecia appear after 7-10 days in culture, are flask-shaped, black, with a spheroidal base, 240-380 µm in diameter, and with an erect beak 250-450 µm long. Ascospores are hyaline, one-celled, elliptical, 2-3 x 5-10 µm, exuded in a sticky creamy-white mass.
- ***Pseudopityophthorus* spp.**
  Adults are small bark beetles, 1.5-1.9 mm long.

MEANS OF MOVEMENT AND DISPERSAL

As noted under Biology, *C. fagacearum* normally spreads rather slowly by root grafting and more rarely above ground by insect transmission. International spread on planting material, or vectors carried on it, is presumably possible although the disease is in practice reported from forest trees rather than from nursery plants. Thus, oak wood carrying sporulating mats of the fungus is the main practical pathway which has been envisaged for international spread. If the wood carries bark, oak bark beetles are more likely to be present and provide an immediate pathway for transmission.

PEST SIGNIFICANCE

Economic impact

Through most of its range, oak wilt is not a serious problem to the local forest economy. Thus in West Virginia less than one tree per km^2 of oak forest dies each year. However, in parts of Minnesota and Wisconsin, rapid mortality is occurring in woods of *Quercus ellipsoidalis*. These woods are of little importance as sources of logs and sawn wood but have high amenity value, especially near the bigger towns and cities. The disease is also killing many *Q. fusiformis* in Texas.

Control

Control measures are only practised in a few parts of the disease range. They rely principally on the avoidance of pruning during the period of peak susceptibility to insect-vectored infection in spring, and the use of chemical or mechanical means to stop the spread of disease through grafted root systems.

Phytosanitary risk

C. fagacearum is an A1 quarantine pest for EPPO (OEPP/EPPO, 1979) and is also of quarantine significance for IAPSC and NAPPO. It is perceived to constitute a very real threat to the EPPO region because of the susceptibility of the major European oak species

and their potential for root graft transmission of the disease. The white oaks, *Q. robur*, *Q. petraea*, *Q. suber* and *Q. ilex* are very important forest and plantation trees in the EPPO region. North American red oaks such as *Q. rubra* have been extensively planted in some countries (e.g. in France). The occurrence in the EPPO region of insects which appear to have the potential to be highly effective vectors, e.g. the European bark beetle (*Scolytus intricatus*) (Doganlar *et al*., 1984; Gibbs *et al*., 1984), also adds to the risk. The entry in the EPPO A1 list includes the vectors of *C. fagacearum*, without specifically naming them, while the EU Annex names *Arrhenodes minutus*, *Pseudopityophthorus minutissimus* and *P. pruinosus*. There is no foundation for considering *A. minutus* (oak timber worm) as a vector. In particular, the duration of the larval stage (2-4 years) is too long for an effective link with *C. fagacearum* in a dead tree to be established. Although the *Pseudopityophthorus* spp. certainly are vectors, it is not certain that it is useful to mention them specifically as quarantine pests, because they are not important in their own right as pests, because they play a relatively minor role in dissemination (less than the presumed potential role of the European *S. intricatus*), because they are not the only species involved, and because the measures taken against *C. fagacearum* will exclude them in any case, together with other vectors.

PHYTOSANITARY MEASURES

EPPO recommends (OEPP/EPPO, 1990) that import of plants for planting of *Quercus* from USA should be prohibited. For wood from USA, three options are offered: (1) removal of all bark and natural rounded surface; (2) kiln drying; (3) fumigation. These requirements are in fact recommended for *Castanea* also, which does not appear justified on the basis of the information in this revised data sheet.

Research in the USA by Englerth *et al.* (1956) on kiln drying, and by Jones (1973) on heat treatment, have been the basis for the EPPO requirements. The possibility of fumigation is principally relevant for red oak logs with bark attached, intended for the veneering industry. The fumigation method (OEPP/EPPO, 1988) is based on the work of Liese & Rütze (1985). White oak logs are perceived to pose a very much smaller risk and could possibly be imported without fumigation during the months October to April (Liese & Rütze, 1987).

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