CANKER STAIN DISEASE OF ORIENTAL PLANE IN GREECE

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Introduction

Oriental plane (*Platanus orientalis* L.) is native in the Balkan Peninsula, extending eastward to Asia Minor, Iran and central Asia. It is a valuable, fast-growing forest tree species, occurring naturally in a large part of Greece, mainly on moist sites along streams and rivers. It is also commonly planted as an ornamental in Greece, being one of the characteristic features of village squares and recreation areas close to natural springs. Oriental plane is a long-living tree attaining large dimensions, among the largest tree species in the country. In many areas of Greece there are centuries-old plane trees of historic value, and some of them have been declared as "Protected Monuments of Nature".

Canker stain, caused by *Ceratocystis platani* (Walter) Engelbrecht et Harrington (syn.: *Ceratocystis fimbriata* Elis & Halstead f. *platani* Walter), is a fatal disease of plane trees. It was reported in Greece in 2003 (Tsopelas & Angelopoulos 2004). The fungus is of American origin (Engelbrecht et al. 2004); it was introduced into Europe from the United States during World War II, possibly with infected plane wood that was used to package ammunitions or other war material. It has caused severe attacks in Italy and France and has also been reported in Switzerland (Panconesi 1999).

Ceratocystis platani infects only species of the genus *Platanus*. Oriental plane is very susceptible to the disease. American sycamore (*Platanus occidentalis* L.) is more resistant to this pathogen. London plane [*Platanus acerifolia* (Ait.) Willd.], which is a hybrid between oriental plane and American sycamore, is very susceptible to the disease (Vigouroux and Olivier 2004, Engelbrecht and Harrington 2005).

Fungal biology and disease symptoms

Ceratocystis platani is primarily a wound parasite; infections can only occur through wounds in the branches, the trunk, or the roots. The fungus initially colonizes the phloem and/or the sapwood exposed by the wound and then spreads into the vessels of the sapwood, advancing longitudinally upwards and downwards. It also grows radially in the medullary rays. The fungus may cause necrosis of the cambium and inner bark to form cankers. Subsequent spread of the pathogen, once introduced into a new site, occurs through root grafts from infected trees into healthy adjacent ones (Walter et al. 1952, Panconesi 1999).

In most oriental plane trees, the cankers are not externally visible because the bark of the trunk is usually thick and roughened. When the outer bark is cut away, necrosis in the inner bark and the sapwood become evident, appearing bluish-black to reddish-brown. Formation of typical cankers on stems is not always observed because most infections of oriental planes along streams occur through the roots. The most common symptom is the presence of the characteristic staining in the sapwood of the infected trunk or branches. In cross section, the stained sectors are often lens-shaped and extend towards the centre of the stem. The most obvious macroscopic symptom of the disease is the sudden wilting of a part of the crown. A branch or the entire tree may fail to sprout in the spring, or the emerging leaves will suddenly wither and die before they attain full size.

Ceratocystis platani is an ascomycete; it produces perithecia, which contain asci with characteristic hat-shaped ascospores. The ascospores ooze from the base of the perithecium through a long neck and accumulate in a sticky mass at apex of the perithecium for insect dispersal. It also forms three different types of asexual spores: cylindrical endoconidia, doliform endoconidia and thick-walled aleurioconidia (chlamydospores) (Engelbrecht and Harrington 2005). The pathogen sporulates on wounds within a few days after infection, before extensive colonization of the plant tissues. In infected trees the fungus produces asexual as well as sexual spores in the region of the canker, in cracks under the bark, as well as on cut or broken surfaces of bark and wood. Spores are also formed in the sawdust that is produced during felling operations of infected trees. It produces aleurioconidia inside the xylem vessels and can survive in the wood of dead trees for months to years. It can also survive, mainly in the form of aleurioconidia, in river water and the soil near the infected trees (Grosclaude et al. 1991)

Spread of the disease in Greece

The disease is mainly spread into new areas by human activities. According to EPPO (1997), the most probable means of international spread is with the transport of planting material or wood from diseased trees. Greece has been importing plane trees from other European countries for the past two decades. London plane is the main *Platanus* species imported to Greece, and the majority of the trees come from Italy. In a recent study, using nuclear and mitochondrial markers, Greek isolates were identical to Italian, Swiss and French isolates, suggesting that the pathogen was introduced into Greece from Italy, France or Switzerland (Ocasio-Morales et al. 2005). If it were introduced on live plant material, Italy would be the likely source. The pathogen may have been in Greece for many years before its detection in 2003. Plane tree mortality due to unknown causes had been observed in the Messinia prefecture for more than a decade before the detection of the disease.

Up to the present *C. platani* has only been detected in southwestern Peloponnese. The disease has been detected in many different localities over an area of about 400 km^2, confined mainly in the Messinia prefecture. It has also been found in a few areas in the neighbouring prefectures of Ileia and Arcadia. The main host affected is oriental plane, while in a few cases infected London plane trees have also been observed. The disease has killed ornamental trees of different ages and sizes in residential areas and recreation sites. However, most of the trees affected by the disease have been in natural stands along streams and rivers. Dead and dying oriental planes have been observed in many of the streams and rivers of Messinia prefecture. In some cases diseased trees have been found along 10 km or more of infested streams.

New infection foci have been found to be centered around trees that were wounded by cutting tools or terracing machinery. Pruning of plane trees is not frequent in Greece, even on ornamental trees in cities, but cutting tools (chainsaws, axes etc.) are often used on diseased trees and then on healthy trees. Terracing machinery also seem to play an important role in the spread of the disease in Greece by carrying infested soil and/or infected wood pieces from diseased to healthy areas. Such machinery may cause damage to the roots of plane trees, creating infection courts. The pathogen can survive for long periods of time in sawdust from diseased trees. The sawdust may be transported to long distances by wind, machinery, or stream water (Walter et al. 1952, Panconesi 1999).

The pathogen may spread readily through running water of streams and rivers. The riparian nature of oriental plane results in trees growing closely together along the sides of streams and rivers with grafted roots. This facilitates the spread of the canker stain fungus. Dead logs and pieces of branches from killed trees may be carried by the water downstream, creating new infection foci. The aleurioconidia of the fungus may also be carried with the stream water and cause new infections (Grosclaude et al. 1991). Once an infection focus is established, the fungus may spread to neighbouring trees through root grafting.

The infected wood by *C. platani* has a fruity odor that attracts different kind of insects, and this has also been observed with other species of *Ceratocystis* on different woody hosts. Crone (1962) reported the transmittance of *C. platani* by beetles of the family Nitidulidae. However, no detailed studies have clearly demonstrated the initiation of new infections on plane trees through nitidulid activity. We have observed infestation of recently dead and dying infected oriental planes by wood-boring ambrosia beetles, and ambrosia beetles (Curculionidae: Scolytinae and Platypodinae) are known to disperse related species of *Ceratocystis* by expelling infested frass outside of the trees during beetle tunneling (Engelbrecht et al. 2004, Engelbrecht and Harrington 2005). The ambrosia beetle *Platypus cylindrus* F. (Platypodinae) has been identified attacking diseased oriental plane in Greece, and *C. platani* has been isolated from the frass expelled outside of the trees (Tsopelas unpublished). Attack by these insects seems to occur only after the plane tree is already infected. Therefore, the ambrosia beetle is probably not important as a vector. However, the frass produced by the ambrosia beetles can be easily dispersed by wind or river water, and it would be infective if it lands on the wound of a healthy tree.

In natural forests of the moderately susceptible *P. occidentalis* in the USA, infections by *C. platani* are usually at low levels (Walter et al. 1952). However, in natural stands of *P. orientalis* in southwestern Peloponnese there is widespread mortality, and the pathogen has the capacity to completely eliminate the local host. This is mainly because oriental plane seems to be a highly susceptible host, even more susceptible than London plane (Vigouroux, personal communication). The pathogen has the potential to spread from Peloponnese to the rest of the mainland, and then eastward to other countries in the natural geographic range of *P. orientalis*.

Control measures

Phytosanitary measures should be applied to avoid further spread of the disease into new areas. A key factor in applying effective control measures is the early detection of new disease foci. Active surveillance in all of Greece is needed. In areas of limited infestation, the application of disease suppression treatments will be more effective and the cost relatively low. In some areas of Messinia prefecture, however, the disease appears to have already reached unmanageable levels.

The most important sanitation measure is the removal and destruction of diseased trees. Infected trees, as well as their neighbouring trees that are suspected of being infected, must be felled and if possible uprooted. The wood as well as all the debris and sawdust should be destroyed by fire, or properly buried in sanitary landfills. The felling site, including the debris and sawdust left, should be sprayed with a fungicide (EPPO 1997, Panconesi 1999). In France, ortho-phenyl-phenol and quaternary ammonium are used as disinfectants (Vigouroux, personal communication). All the tools used in felling operations should be disinfected. If removal is not possible, living infected trees should be injected with a herbicide. Herbicides can also be injected into healthy trees neighbouring infected trees to create a buffer zone and minimize the risk of root transmission (Panconesi 1999). In France, the herbicide glyphosate is used to kill infected and neighbouring trees (Vigouroux, personal communication).

Dissemination of *C. platani* may occur over long distances by terracing machinery, cutting tools, planting stock or infected wood. Terracing machinery used in the vicinity of infected trees should be disinfected before leaving the site; they should be cleaned with a water-jet and then sprayed with a disinfectant (EPPO 1997). Planting material should be obtained from disease-free regions, and all imported plane trees should be inspected. Resistant hybrids (between *P. occidentalis* and *P. orientalis*) have been developed recently (Vigouroux and Olivier 2004), and these can be used in Greece. Harvesting of firewood from trees killed by the disease should be forbidden, because the fungus may survive and be spread to new regions in wood.

The presence of canker stain of plane tree in Greece is particularly alarming because the pathogen is now present in natural stands of a highly susceptible species. Oriental plane has tremendous historical, aesthetic and ecological importance, and all efforts should be taken to limit the spread of the pathogen throughout the natural range of this host.

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