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PHYTOPHTHORA CACTORUM, P. RAMORUM, P. PLURIVORA, MELAMPSORIDIUM HIRATSUKANUM, DOTHISTROMA SEPTOSPORUM AND *CHALARA FRAXINEA*, NON-NATIVE PATHOGENS IN FINLAND

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ABSTRACT

International trade and travel increase the risk of pest spread. Climate change might also improve the establishment of introduced species into new geographical areas. The ornamental trade has shown to be an important source of alien Oomycetes, especially *Phytophthora* species.

Two other pathogens, which have recently arrived in Finland, are ascomycetes *Chalara fraxinea* and *Dothistroma septosporum*. The typical symptoms of red band needle blight were found on *Pinus sylvestris* in many locations in summer 2007 and 2008. Isolations from acervuli on needles resulted in pure cultures of *D. septosporum,* the anamorph of *Mycosphaerella pini*. First signs of ash decline were found on *Fraxinus excelsior* in 2007. Although ash is indigenous only in southern Finland, the species can be cultivated in the central region. Thus far, *C. fraxinea* has only been isolated from trees in southwest Finland and Åland archipelago.

NON-NATIVE PATHOGENS IN FINLAND

Phythophthora cactorum

In Finland, *Phytophthora cactorum* was isolated for the first time in 1990 from strawberry (*Fragaria* x *ananassa*) plants suffering from crown rot. A year later it was isolated from necrotic stem lesions of silver birch (*Betula pendula*) seedlings (Fig. 1) growing in forest nurseries (Lilja and others 1996, Hantula and others 1997, 2000). Since then, this imported pathogen has caused crop losses in strawberry fields mainly as an agent of crown rot and increased the culling of infected birch seedlings in forest nurseries.

The crown rot isolates from strawberry within Europe have shown to be genetically identical (Hantula and others1997, 2000, Lilja and others1998, Eikemo and others 2004). This suggests that it is more obvious that *P. cactorum* has spread within seedling material than due to natural dispersal. The movement of *P. cactorum* on birch stays unclear since genetic analysis has been done only with isolates from Finland (Hantula and others1997, 2000, Lilja and others 1998, Eikemo and others 2004).

We have monitored the effect of *P. cactorum* infection on container-grown silver birch seedlings in the nursery and after out-planting (Lilja and others 1996, 2007a, Lilja and others unpublished). In two experiments, diseased and healthy silver birch seedlings were out-planted. Each seedling was assessed using a scale of 1 to 4 where: 1= no lesion 2 = lesion < 5 mm^2 3 = lesion > 5 mm^2 but not covering over half of the stem diameter and 4 = lesion spread over half of the stem diameter but not girdling the stem. In the nursery, stem lesions affected the growth and seedling shoot height was related to disease severity. Asymptomatic birches were taller than diseased individuals and the shortest were those with stem lesions covering over half of their stem diameter (Lilja and others 1996, 2007a, Lilja and others unpublished). Seedling height growth in reforestation areas was directly related to disease rating. The shortest seedlings with stem lesions covering over half of their stem diameter grew more than the taller seedlings (healthy controls or seedlings with smaller stem lesions). Thus, differences in shoot heights between diseased and apparently healthy seedlings in the nursery reduced dramatically but did not disappear after out-planting. However, seedling mortality increased with disease severity (Lilja and others 1996, 2007a, Lilja and others unpublished).

Figure 1. Stem lesion caused by *Phytophthora cactorum* on *Betula pendula* seedling (A. Lilja).

Phytophthora ramorum
A new species of *Phytophthora, P. ramorum* was described by Werres and others (2001) and found associated with a twig blight on rhododendron (*Rhododendron* spp.) and viburnum (*Viburnum* spp.) in Germany and the Netherlands. Later, the same species was found to be responsible for Sudden Oak Death (SOD) of oaks (*Quercus* spp.) and tanoaks (*Lithocarpus densiflorus*) in California (Rizzo and others 2002, 2005, Davidson and others 2005). Although the pathogen has been detected on a few trees in Europe (Brasier and others 2004), our continent has so far been spared the SOD epidemic seen in western North America.

In spring 2004, *P. ramorum* was found for the first time in Finland. It was isolated after a positive PCR-reaction from commercial rhododendron plants originating from other EU member states (Lilja and others 2007b). In the following August, the pathogen was also isolated from rhododendrons (*Rhododendron catawbiense* and several other cultivars) produced by micropropagation in a Finnish nursery (Lilja and others 2007b). Since then, the Finnish Food Safety Authority (Evira) has carried out extensive surveys in the nursery. Today, we know that the pathogen remains in the nursery, although all rhododendron seedlings and growth media have been destroyed every year in the area where the infection has been found. Routine examinations rely on a *P. ramorum*-specific PCR and isolation from positive samples, as well as verification of morphological identification by partial β-tubulin gene sequencing (Lilja and others 2007b).

Risk analyses assume that the consequences of pest introduction are positively correlated with a pests host range (Cave and others 2005). *P. ramorum* has many hosts in different plant families (Knight 2002, Denman and others 2005). In pathogenicity tests run by us, *P. ramorum* caused stem lesions on silver birch and common alder but Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) were resistant (Lilja and others 2007b). On English oak (*Quercus robur*), the tree species present in southern Finland, *P. ramorum* only caused minor lesions or no lesions.

Phytophthora plurivora

P. plurivora used to be included in the *P. citricola* species complex, but was recently separated from it and described as a new species (Jung & Burgess 2009). This species seems to be abundant in forests, semi-natural ecosystems and nurseries across Europe, causing bark necroses, fine root losses and dieback on at least 11 woody host species, including *Quercus robur* (Jung and Blaschke 1996)*, Alnus glutinosa* (Jung and others 2005, Jung and Nechwatal 2008) and *Picea abies* (Nechwatal and Oβwald 2001). We have isolated *P. plurivora* since 2004, originally from rhododendron cultivars known to be infected with *P. ramorum* (Lilja and others 2007b). In 2007, *P. plurivora* was also isolated from *Syringa* sp. Originally, our *P. plurivora* isolates were identified as *P. inflata*. The identification was supported by the fact that the beta-tubulin sequence of *P. inflata* IMI 342898 (isolated from *Syringa vulgaris* in the UK) in the GenBank had 100 % match with our isolates. However, the species status of *P. inflata* has been changed, since the original type isolate (Caroselli and Tucker 1949) has been lost, and it is clear that the isolates identified as *P. inflata* should be re-assigned to other species of the *P. citricola* complex including *P. plurivora* (Jung and Burgess 2009).
In our pathogenicity trials, *P. plurivora* was able to infect most of the tested host plants including strawberry, silver birch, common alder, grey alder, Norway spruce (Fig. 2) and lingonberry. The only resistant woody species in our trials was Scots pine.

Melampsoridium hiratsukanum

In the mid-1990s, an epidemic of foliar rust on *A. glutinosa* and *A. incana* was observed in Estonia and Finland (Põldmaa 1997, Kurkela and others 1999). The morphological similarity of the pathogen to *M. hiratsukanum* was noted and recent work confirmed the species identification (Põldmaa 1997, Kurkela and others 1999, Hantula and others 2009). The infection causes considerable damage to *Alnus* foliage in late summer, when diseased trees can easily be seen from a distance. The whole foliage turns brown and leaf margins curl inward. Successive infections can cause tree death.

Figure 2. *Phytophthora plurivora* infection on inoculated *Picea abies* seedling (left) and a control (A. Lilja).

A comparison of urediniospore morphology of *M. hiratsukanum* found no differences among material originating from Austria, Estonia, Finland, Japan, or Switzerland (Hantula and others 2009). Furthermore, sequence analysis of the ITS region for a selection of these samples detected only minor differences and reveal *M. hiratsukanum* in East Asia and Europe to belong to a single palearctic population (Hantula and others 2009). Thus, as proposed earlier by Kurkela and Hantula (1999), it seems likely that spores arriving from East Asia caused the recent European epidemic in foliar rust on *Alnus* spp.

Dothistroma septosporum - Mycospaerella pini

Red band needle blight caused by *Dothistroma septosporum* is an economically important disease causing premature defoliation. The perfect stage of *D. septosporum* is *Mycospaerella pini* (Barnes and others 2004). The typical symptoms of red band needle blight were found on Scots pine (Fig. 3) during the summers of 2007 and 2008 in 14 rural districts of southern and central Finland (Müller and others 2009). Red bands with aggregations of conidial stromata on otherwise brown attached needles were frequently encountered on saplings and young trees in dense stands and sporadically on lower twigs of mature trees (Müller and others 2009). Disease symptoms were also observed on the needles of contorta pine (*Pinus contorta*) and cembra pine (*P. cembra*), which occur in Finland at a low frequency (Müller and others 2009).

Figure 3. Red bands caused by *Dothiostroma septosporum* on needles of *Pinus sylvestris* (M. Müller).

Pure cultures of *D. septosporum* were isolated from acervuli on needles of pine trees growing in forest conditions and their identification was verified by sequencing (Müller and others 2009). Sequences of the ITS-region (including 5.8SrRNA gene) obtained from the Finnish isolates were identical to each other and over 50 published sequences of *D. septosporum* (Müller and others 2009). In a nursery experiment, brown segments and red bands appeared on inoculated 1-year-old seedlings of Scots pine within a month and conidial stromata could be seen on needles 2 to 4 weeks after the first symptoms (Müller and others 2009). Results from the inoculation experiment and probable aerial dissemination suggest that *D. septosporum* likely occurs in Finnish nurseries although the low number of pines produced and routine application of fungicide restrict its detection and limit its establishment.

Chalara fraxinea - Hymenoscyphus sp.

During recent years, common ash (*Fraxinus excelsior*) in Europe has shown a large-scale decline. The symptoms include 1) wilting and premature shedding of leaves, 2) necroses of leaves, buds, leaf stalks and bark, 3) top and shoot dieback, and 4) cankers on shoots, branches and stems (Fig. 4). The fungus *Chalara fraxinea* is shown to be responsible for the disease (Kowalski 2006, Kowalski and Holdenrieder 2009a, Bakys and others 2009a, b). Kowalski and Holdenrieder (2009b) have suggested that the teleomorph of *C. fraxinea* is *Hymenoscyphus albidus*, an ascomycete, which has been known in Europe for a long time and is considered a harmless decomposer of fallen leaves (Ellis and Ellis 1997). However, some recent studies have found certain genetic differences among

Hymenoscyphus isolates in areas devastated by the disease, as compared with areas where the disease has not yet been observed (H. Solheim and B. Marcais unpublished).

Figure 4. *Chalara fraxinea* infection on achene of *Fraxinus excelsior* (A. Lilja).

In Finland, the first signs of ash decline were seen in 2007. Although ash is native only in southern Finland, the species can be cultivated in the central region. Thus far, *C. fraxinea* has only been isolated from trees growing in their native range in southwest Finland and Åland archipelago (Rytkönen and others 2010).

The teleomorph is wind-transmitted and likely more important to dispersal than the sticky conidia of *C. fraxinea* (Kowalski and Holdenrieder 2009). *C. fraxinea* may be able to disperse in plants or wood. Although insect vectors are important in the dispersal of several species of *Chalara* (Nag Raj and Kendrick 1993), none have been identified for *C. fraxinea*. However, the symptoms of infection include, and are often similar to, those seen on trees infested by the emerald ash borer (*Agrilus planipennis*) in North American ash.

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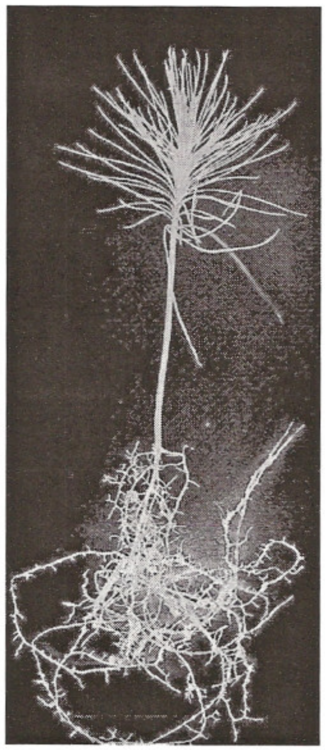

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