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Data Sheets on Quarantine Pests

Cronartium fusiforme

IDENTITY

Name: *Cronartium fusiforme* Hedgcock & Hunt ex Cummins
Synonyms: *Cronartium quercuum* (Berkeley) Miyabe ex Shirai f.sp. *fusiforme* Burdsall & Snow
Anamorph: *Peridermium fusiforme* J.C. Arthur & Kern
Taxonomic position: Fungi: Basidiomycetes: Uredinales
Common names: Southern fusiform rust (English)
Notes on taxonomy and nomenclature: The North American literature mostly refers to *C. fusiforme* as a *forma specialis* of *C. quercuum*, and distinguishes several other *formae speciales* (EPPO/CABI, 1996).
Bayer computer code: CRONFU
EPPO A1 list: No. 9
EU Annex designation: I/A1 - as *Cronartium* spp. (non-European)

HOSTS

The aecial hosts of *C. fusiforme* in North America are twoand three-needled *Pinus* spp., of which the most important in practice are the southeastern species slash pine (*P. elliottii*) and loblolly pine (*P. taeda*). Other species which are occasionally attacked are pitch pine (*P. rigida*) and pond pine (*P. serotina*). Some major southeastern species are resistant - longleaf pine (*P. palustris*), shortleaf pine (*P. echinata*). *C. fusiforme* has a rather restricted geographical distribution in USA, with the result that the majority of North American *Pinus* spp. do not occur in its range. Though some of these are resistant (e.g. red pine, *P. resinosa*; jack pine, *P. banksiana*), practically all can be experimentally infected to a certain extent and some are highly susceptible. In an experimental study of seedlings of 45 species from North America, Central America, the Caribbean, Asia and the Euro-Mediterranean region, all but one (*P. resinosa*) showed some infection, and twelve species were more susceptible than the susceptible standard (*P. elliottii*) (Tainter & Anderson, 1993). Of particular interest for the EPPO region was the fact that the fairly widely planted North American species lodgepole pine (*P. contorta*), western yellow pine (*P. ponderosa*) and Monterey pine (*P. radiata*) were all fairly susceptible. Important European species which were relatively susceptible included Canary island pine (*P. canariensis*), Aleppo pine (*P. halepensis*), some forms of *P. nigra*, and umbrella pine (*P. pinea*). Mountain pine (*P. mugo*) and maritime pine (*P. pinaster*) were less susceptible. Scots pine (*P. sylvestris*) was not tested, but is not elsewhere mentioned as susceptible. Species from Central America, the Caribbean and Asia were also susceptible. Overall, fusiform rust seems to attack the *Pinus* spp. of warmer areas rather than the northern species, whether in the New or the Old World.

The telial hosts in North America are mainly *Quercus* spp., of the red oak group and generally not the white oak group. Typical host species are water oak (*Q. nigra*) and willow oak (*Q. phellos*). North American *Castanea* spp. such as *C. dentata* have also been recorded as hosts. Records on *Fagus*, and on the non-fagaceous genera *Carya* and *Ostrya*, seem of questionable significance. For more information, see Spaulding (1956, 1961), Boyce (1961), USDA (1963), Davidson & Prentice (1967), Peterson (1967), Hepting (1971), Ziller (1974).

GEOGRAPHICAL DISTRIBUTION

EPPO region: Absent.
North America: USA (mainly in the coastal southeastern states - Alabama, Arkansas, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Texas, Virginia, West Virginia).
EU: Absent.
Distribution map: See CMI (1977, No. 475).

BIOLOGY

The biology of all the heteroecious North American *Cronartium* spp. is broadly the same, and the following general account can be applied to *C. fusiforme*. Pycnia and aecia are produced on the *Pinus* hosts in the spring and early summer, one to several years after infection. Aeciospores can be carried over long distances in the wind and infect the alternate (telial) host; they cannot reinfect *Pinus*. About 2 weeks after infection, uredinia appear on the alternate hosts. Successive production of uredinia and reinfection throughout the summer result in high levels of infection on the alternate host. Telia are produced in late summer, and *Pinus* hosts become infected via the first-year needles by the wind-borne basidiospores which arise from germination of teliospores; the telial host cannot be reinfected by basidiospores. Basidiospore infection, which occurs in summer and autumn, is usually limited to an area within 1.5 km of the alternate host, owing to the spores being delicate and short-lived. Infection of *Pinus* by basidiospores completes the life cycle, the duration of which varies between rusts. The fungal mycelium of these rusts may overwinter in bark and galls of *Pinus*.

C. fusiforme penetrates epidermal cells directly; there is then rapid and profuse colonization of the mesophyll and endodermis, resulting in partial to complete host-cell dissolution. Attacks by the lepidopteran pest *Rhyacionia frustrana* apparently favour infection of *P. taeda* by *C. fusiforme* (Hedden *et al*., 1991). Schmidt *et al.* (1988) have analysed the site factors which favour fusiform rust in young plantations in Florida and Georgia (USA). For more information, see also Boyce (1961), USDA (1963), Davidson & Prentice (1967), Peterson & Jewell (1968), Peterson (1973), Ziller (1974), Sinclair *et al.* (1987). The widely distributed and much studied *C. ribicola* has similar biology.

DETECTION AND IDENTIFICATION

Symptoms

On *Pinus*, typical spindle-shaped, elongate stem and branch galls form, growing at a rate of 7-12 cm annually. Old infections develop into sunken cankers, while seedling infection results in a witches' broom appearance. On the alternate host, *Quercus*, inconspicuous leaf spots occur, unless the infection is severe, in which case there may be some abscission.

Morphology

Aecia erumpent, with thin walls, one to two cells thick. Aeciospores coarsely verrucose; 13-18 x 22-28 µm. Urediniospores evenly and sharply echinulate; 12-15 x 17-21 µm. Telia brown 104 x 2872 µm. Teliospores 14.5-36.4 µm. The fungus was first cultured by Hu & Amerson (1991).

Detection and inspection methods

Isozyme and protein analysis can differentiate between *C. fusiforme, C. quercuum* and *Endocronartium harknessii*. An ELISA test for *C. fusiforme* in *Pinus* seedlings has been developed, but not yet applied in practice (Spaine, 1987). Random amplified polymorphic DNA markers may be used to "fingerprint" individual isolates of *C. fusiforme* (Doudrick *et al.*, 1993a; 1993b).

MEANS OF MOVEMENT AND DISPERSAL

Cronartium spp. can be carried considerable distances as wind-borne aeciospores and can survive considerable periods in the airborne state (Chang & Blenis, 1989). More importantly, these rusts can be carried to new areas on plants for planting of the coniferous aecial hosts, as has occurred in parts of the USA. The long incubation periods of *Cronartium* rusts mean that latent infections easily go undetected unless post-entry quarantine is applied. The alternate hosts of *C. fusiforme* are wild woody plants, many of which are unlikely to be traded internationally; however, some *Castanea* and *Quercus* spp. could enter trade. In this case, because they are deciduous and infection is restricted to the leaves, there should be no risk in shipment of dormant material. Similarly, there is no risk in movement of *Pinus* seeds or pollen.

PEST SIGNIFICANCE

Economic impact

The *Cronartium* rusts cause very important diseases throughout the world, resulting in malformation, reduced vigour and death of trees and seedlings. However, their abundance does depend primarily on the abundance of the alternate host (Gross *et al.*, 1983). *C. fusiforme* causes the most serious forest-tree disease in the southern USA, especially on *P. taeda* and *P. elliottii*, attacking *Pinus* immediately after germination onwards (damage to *Quercus* is insignificant). Stem-girdling galls are particularly damaging (Walkinshaw & Roland, 1990). Much more information is published on this *Cronartium* species than on all the North American *Cronartium* spp. of conifers put together. In 1952, annual losses were put at 90 million board m of *Pinus* saw-timber and 0.0769 million m^3 of growing stock, worth in total 28-30 million USD in stumpage value and 150 million USD in finished wood products. There has been a considerable increase in severity of the disease, and losses in the 1970s were estimated at twice the 1952 level. In northern Florida alone, 0.0147 million m^3 of wood worth 3.9 million USD was lost in 1974 (Phelps & Chellman, 1975). More recent estimates have been published by Anderson *et al*. (1986), together with hazard maps for the disease (Anderson *et al.*, 1988). Equations have been developed to predict survival of *Pinus elliottii* infected by fusiform rust (Devine & Clutter, 1985). For more information on the pest significance of *Cronartium* spp., see also Boyce (1961), Peterson & Jewell (1968), Ziller (1974), Sinclair *et al.* (1987).

Control

Control can be effected by removing infected material. Eradicating the alternate host is not a practical possibility. Nurseries should be located away from possible infection sources. Chemicals can be used as seed treatments or as sprays (Runion *et al*., 1991; Carey & Kelley, 1994; Haywood *et al.*, 1994). Research into resistant cultivars and systemic fungicides (triadimefon) has led to successful control, especially of *C. fusiforme* in forest nurseries (Powers, 1984). Mass selection or breeding of *P. elliottii* and *P. taeda* for resistance to fusiform rust continue to attract considerable research efforts (e.g. Kuhlman & Powers, 1988) and a Cooperative Forest Genetics Research Program of the University of Florida (Gainesville) is now in its 37th year of work in this area. In addition, incidence of fusiform rust is affected by many management practices, which need to be integrated to reduce the incidence of the disease (Miller & Schmidt, 1987).

Phytosanitary risk

C. fusiforme is one of the non-European *Cronartium* spp. of the EPPO A1 list (OEPP/EPPO, 1979). The danger presented by these fungi to the EPPO region is classically exemplified by reference to the quarantine pest *C. ribicola* (Phillips, 1988), which has made it almost impossible to grow *P. strobus* commercially in most areas in Europe and North America to which the fungus was introduced from Asia. As already mentioned, *C. fusiforme* is much the most important *Cronartium* sp. in North America at the present time, and though its main North American hosts are not grown in the EPPO region, other North American hosts are widely planted in parts of the EPPO region, while certain European, and especially Mediterranean, *Pinus* species have proved experimentally susceptible. Ragazzi (1989) has analysed the risks of introduction of *C. fusiforme* into Mediterranean countries.

It should, however, be stressed that the potential risk from introduced *Cronartium* spp. is much affected by the status of the alternate hosts concerned. The telial hosts of *C. fusiforme* are, in North America, mainly *Castanea* and *Quercus* spp. indigenous to that continent. No information seems to be available on the susceptibility of European species of these genera. The most widespread European oaks are "white oaks" (subgenus *Quercus*), and thus belong to the group which is not susceptible in North America. North American red oaks are planted to a limited extent in Europe (e.g. *Q. rubra*, but not the main southeastern species).

The European evergreen oaks could be susceptible, but there is no direct evidence of this. Kuhlman & Matthews (1993) mention propagation of single-aeciospore isolates of *C. fusiforme* on the Asian species *Q. acutissima*. Tainter & Anderson (1993) mention that the Californian *Q. kelloggii* is as susceptible as the southeastern *Q. nigra*, and imply that the propensity of *C. fusiforme* to attack "exotic" aecial hosts could be matched by a similar propensity to attack "exotic" telial hosts. However, this remains conjectural, and it is a point of fundamental importance that the establishment of *C. fusiforme* in the EPPO region depends on its finding a reasonably frequent telial host occurring in the same areas as the aecial hosts. Only introduced *Q. rubra* possibly qualifies in this respect.

In favour of the importance of *C. fusiforme* as a quarantine pest for the EPPO region is the fact that this is a very serious disease in North America, that several European species of *Pinus* have been found to be experimentally susceptible (but not *P. sylvestris* and only to a limited extent *P. pinaster*), and that several widely planted North American species are susceptible. On the other hand, no European species has been specifically recorded as a telial host and North American red oaks are planted in Europe to only a rather limited extent. Accordingly, *C. quercuum* can be considered to present a definite risk for the EPPO region, but one which would be much more clearly defined if the status of European *Quercus* spp. as potential telial hosts were systematically examined.

PHYTOSANITARY MEASURES

Since symptoms may not be apparent for many years after infection, the only practical safeguard is to prohibit entry of the *Pinus* hosts from countries where *C. quercuum* occurs (OEPP/EPPO, 1990). *Castanea* and *Quercus* spp. should only be imported in a dormant state, without leaves. Bark and wood of *Pinus* should have been appropriately treated (heat-treated, fermented, kiln-dried; EPPO quarantine procedures are in preparation).

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