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First Report of Pitch Canker Disease on *Pinus rigida* in Korea

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Pitch canker of *Pinus rigida*, caused by *Fusarium subglutinans* f. sp. *pini*, was first noticed in Inchon, Korea, and is now being spread into other plantations of pines. Typical symptoms are resin flows from cankers on the shoots, branches, and trunks, and resin-soaking of the sap wood under the bark. Pathogenic fungi were isolated from the infected shoots, branches, and seeds on Fusarium-selective medium. Mycelial growth and microscopic characteristics were examined. Pathogenicity test was carried out by inoculating four common species of pines (*P. rigida*, *P. densiflora*, *P. thunbergii*, and *P. koraiensis*) in Korea. *P. rigida* and *P. thunbergii* showed symptoms identical to those of naturally infected trees, while *P. densiflora* and *P. koraiensis* remained free symptomless.

Keywords : *Fusarium subglutinans* f. sp. *pini*, *Pinus rigida*, *Pinus thunbergii*, pitch canker, resin flow.

In the mid 1990s, pitch pine (*Pinus rigida*) showing symptoms and signs, such as changes of needles into yellow then red, noticeable dieback in the tree crown, resin flows from the infected areas on the shoots, branches, cones, and trunk, resin-soaked wood under the bark, sporodochia in needle scars on shoots, and tree mortality was noticed in the natural and planted areas of *P. rigida* in Seoul, Inchon, Kyunggi, Chungchong, and Kangwon provinces of Korea (Fig. 1A, 1B, 1C).

The disease was first recorded from the southeastern United States (Hepting and Roth, 1946), where it had damaged on Slash pine (*P. elliottii*), Shortleaf pine (*P. echinata*) and Virginia pine (*P. virginia*) (Dwinell et al., 1985). Since then, many pine species have been reported as the host. In 1986, this disease was discovered on Monterey pine (*P. radiata*) in California, where it also affect many other pines and even Douglas fir (*Pseudotsuga menziesii*) (Dallara et al., 1995). It has been reported from Mexico, Japan (Muramoto and Dwinell, 1990), and South Africa (Viljeon and Wingfield, 1994). Pine species showed differences in susceptibility, but most species appear to be susceptible to some degree and 23 species of pine and Douglas fir, so far, has been reported as the host trees (Storer et al., 1998).

The pitch canker pathogen was isolated from the infected branches, twigs, and cone seeds sampled. Cones were collected from the branches with symptoms, and seeds were removed from the cones after drying in an oven for 48h at 40°C. A modified Nash-Snyder medium (FS medium) was used for selective isolation of *Fusarium* (Correll et al., 1991). FS medium consists of 15g of peptone, 1g of KH_2PO_4, 0.5g of $MgSO_4 \cdot 7H_2O$, 1g of pentachloronitrobenzene (PCNB), 20g of agar, and 1 *l* of distilled water. After autoclaving and cooling the medium, 0.05g of triadimefon, 0.1g of ampicillin, and 0.02g of rifampicin were added. Infected parts were dipped in 70% ethanol and flame sterilized. Bark surfaces were removed, pieces of resin-soaked wood were cut from the canker margin, and placed on FS medium. Isolated fungi appears as slow growing, granular, white colonies on FS medium, and then a portion of the colonies were transcultured on Carnation Leaf Agar (CLA) for species identification. The fungus was isolated from most of the infected branches, twigs, and seeds. These result indicate that the fungus is transmitted by the seeds and gives great damges in seed nursery (Storer et al., 1998). Isolated fungus produced characteristic microconidia, macroconidia and polyphialides, but did not produced chlamydospores (Fig. 1D, 1E).

Mycelia grew most actively at 25°C, and retarded by the decrease of incubation temperature and failed to grow at 5°C. Aerial mycelium was produced abundantly and the medium changed into purplish color at 20°C. These characteristics of this fungus might be correlated with the disease distribution of coastal areas where the climate is mild and below freezing temperature are rare (Storer et al., 1997).

The pathogenicity of isolated fungus was tested in a glasshouse by inoculating agar disc containing mycelium or

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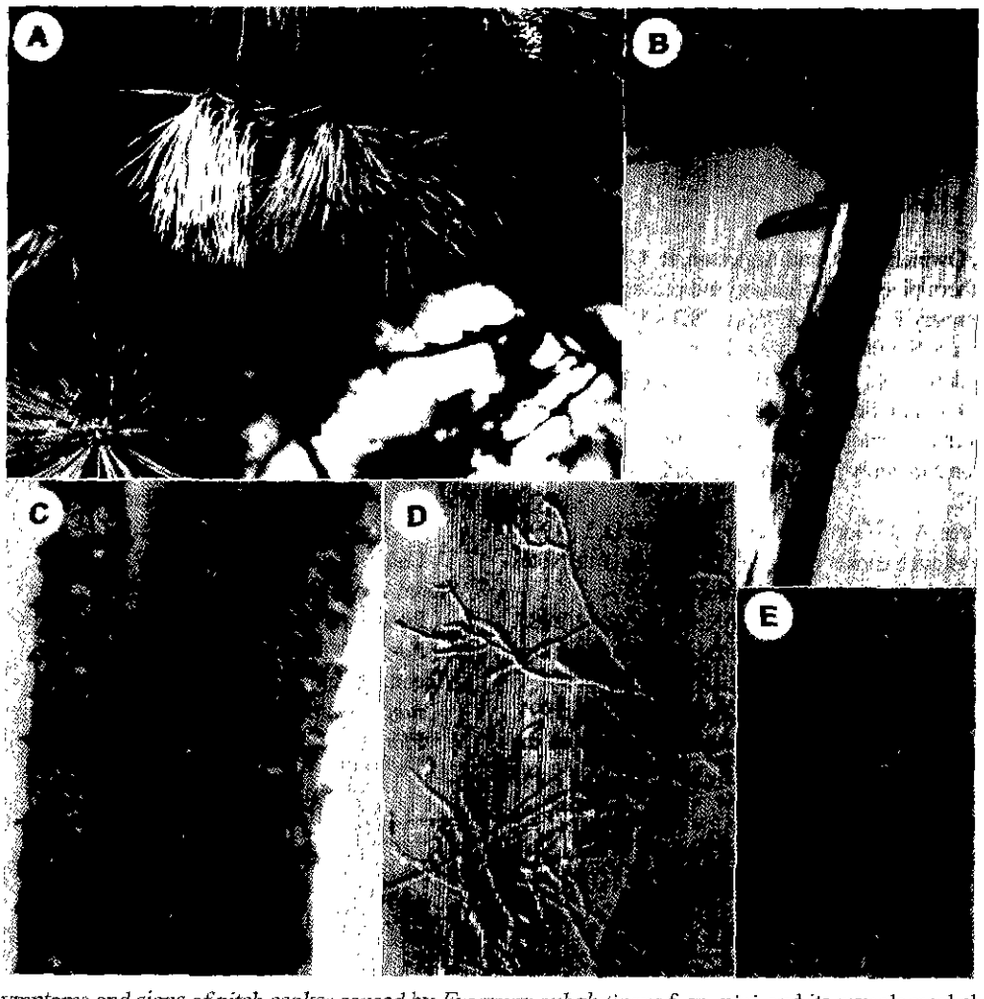

Fig. 1. Typical symptoms and signs of pitch canker caused by *Fusarium subglutinans* f. sp. *pini*, and its mycological characteristics. (A) Early stage symptoms showing reddish-brown needles on the infected twigs recently killed by the pitch canker fungus, (B) Typical symptoms of discolored wood by resin-soaking after removing bark, (C) Sporodochia of the pitch canker fungus formed on needle scars of the infected twigs, (D) Polyphialides, a typical microscopic characteristics of the pitch canker fungus, produced on PDA (×100), (E) Micro- and macroconidia of the pitch canker fungus (×100).

Table 1. Pathogenicity of *Fusarium subglutinans* f. sp. *pini* to four species of pine seedlings

Pine species	Inoculation method	
	Spore suspension[a]	Agar disc[b]
Pinus rigida	++	++[c]
P. thunbergii	–	+
P. densiflora	–	–
P. koraiensis	–	–

[a]Spore suspension (4.6×10^6 conidia/ml) was sprayed on 3-year-old pine seedlings, whose bark surfaces scratched with a sterilized knife for providing infection court.

[b]Agar discs containing mycelium placed in the holes where the bark tissue was removed by a cork borer, and wrapped with parafilm to protect from dessication.

[c]Symptom development: ++: symptoms developed and seedlings dead within 1 month; +: symptoms developed and seedlings dead within 2 months; –: no symptom was developed.

spore suspension (4.6×10^6 conidia/ml) on four species of 3-year-old pine seedlings, i.e., *P. rigida*, *P. densiflora*, *P. thunbergii*, and *P. koraiensis*, which are common pine species in Korea. Stems of inoculated *P. rigida* and *P. thunbergii* were girdled and eventually dead within 4 weeks and 8 weeks after inoculation, respectively, while *P. densiflora* and *P. koraiensis* were remained free from symptoms (Table 1).

Based on these cultural, mycological, and pathological charateristics, this fungus was identified as *Fusarium subglutinans* f. sp. *pini*, which is known as the pitch canker fungus of pine (Nelson et al., 1983). Wounds by wind, hail, and insect such as beetles, weevils, and moths are known as a primary infection court by spores (Fox et al., 1991). Since there is no known cure for the pitch canker, limiting its spread is the key to prevention. Thus, the potential management strategies are minimization of injury to the bark dur-

ing forestry operations including pruning and thinning, reduction of the incidence of insect-causing wounds, and prohibition of transportation of infected woods to uninfested area (Blakeslee et al., 1980).

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