

Resistance to *Phytophthora cinnamomi* in the Genus *Abies*

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Abstract

A major limiting factor for the culture of true firs as Christmas trees is their susceptibility to Oomycete species belonging to the genus *Phytophthora*. In North Carolina alone, the Fraser fir (*Abies fraseri* [Pursh] Poir.) Christmas tree industry loses 6 to 7 million dollars annually to root rot primarily caused by *Phytophthora cinnamomi*. Because no resistance has been found in Fraser fir, in 2003, the North Carolina State University (NCSU) Christmas Tree Genetics (CTG) Program conducted an extensive resistance screening of 32 *Abies* species (50 unique taxa) from around the world.

Overall mortality was high (88 percent), but was less frequent in two of the eight taxonomic sections of the genus evaluated: *Momi* (65.5 percent) and *Abies* (79.3 percent). Species mortality rates in all other sections exceeded 93 percent. Final species mortality ranged from 10.6 percent (*A. firma* Sieb. et Zucc.) to 100.0 percent (several species). Hierarchical cluster analysis was used to classify species into groups representing six levels of resistance, designated as very resistant (*A. firma*), resistant (*A. pindrow* [D. Don] Royle), moderately resistant (four species), intermediate (five species), susceptible (seven species), and very susceptible (17 species).

In the species screening trial, Turkish fir (*A. bornmuelleriana* Mattf.) and closely related Trojan fir (*A. equi-trojani* Coode et Cullen) ranked third and tenth for resistance, but mortality in these species was relatively high. A systematic approach to understand and better use *Phytophthora* resistance within Turkish and Trojan fir was undertaken. Using seeds from a 2005 cone collection expedition to Turkey, greenhouse-grown seedlings from 105 open-pollinated families were inoculated with *P. cinnamomi*. Sixteen weeks after inoculation, overall seedling mortality was 56 percent for Trojan fir and 35 percent for Turkish fir. As a comparison, 97 percent of inoculated Fraser fir seedlings, but only 3 percent of inoculated momi fir seedlings, died. For Turkish and Trojan fir, there was a distinct relationship between mortality and geographic origin; mortality percentage decreased from west to east. Additionally, estimates of family mean heritabilities were extremely high for both Turkish (0.96 ± 0.010) and Trojan (0.97 ± 0.011) fir.

In another approach, hybrid firs are being developed through a collaborative effort between the NCSU CTG Program and researchers at the Czech University of Life Sciences (CULS) Prague. Researchers at CULS have utilized Toros fir (*A. cilicica* Carr.) from southern Turkey and Greek fir (*A. cephalonica* Loud.) in a long-term hybrid breeding effort aimed at developing a faster growing fir that is hardier to changing ecological conditions than the native European silver fir (*A. alba* Mill.). Toros and Greek fir were ranked fourth and eighth, respectively, in the species screening trial. Seedlings of F1, F2, and complex hybrids with Fraser fir are being assessed for *Phytophthora* resistance.

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