

Evaluating Alternative Fir Species for Phytophthora Root Rot Resistance

John Frampton
Christmas Tree Geneticist
North Carolina State University
E-mail: john_frampton@ncsu.edu

Background

Studies employing greenhouse inoculations with *Phytophthora cinnamomi* Rands. have confirmed that Fraser fir (*Abies fraseri* [Pursh] Poir) is extremely susceptible to this pathogen and have demonstrated that some other fir species possess an intermediate or high degree of resistance (Figures 1 and 2). In particular, momi fir (*Abies firma* S. & Z.), sometimes referred to as Japanese or Dixie fir, and Turkish fir (*Abies bornmuelleriana* Mattf.) appear to be highly resistant. Two species, which appear to have intermediate resistance, are Nordmann fir (*Abies nordmanniana* [Stev.] Spach.) and Korean fir (*Abies koreana* Wils.).

Interestingly, Canaan fir (*Abies balsamea* (L.) Mill. var. *phanerolepis* Fern.), a geographic source of a variety of balsam fir, also appears very susceptible to *Phytophthora* root rot when inoculated under greenhouse conditions. This variety has sometimes been planted in the mountains of North Carolina on high *Phytophthora* hazard sites with varying degrees of success. Its ability to survive on sites where Fraser fir would be overcome by *Phytophthora* root rot may be due to its relatively more aggressive ability to regenerate roots and thus "outgrow" the infection (at least for a while).

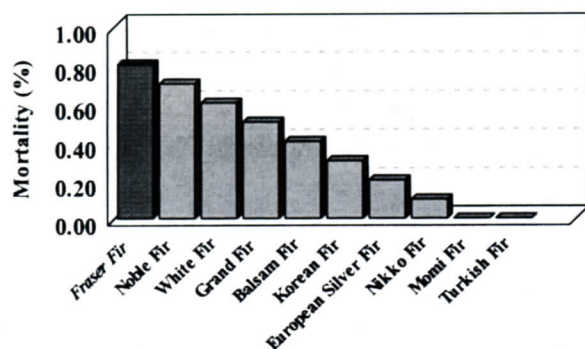


Figure 1. Mortality of 2-0 seedlings of ten fir species inoculated with *Phytophthora cinnamomi*. (Chastagner 1999)

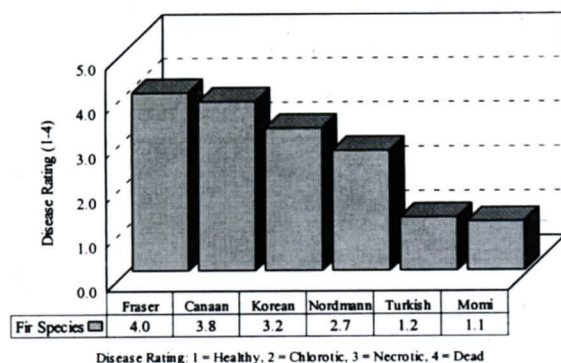


Figure 2. Disease score ratings of five fir species inoculated with *Phytophthora cinnamomi* (Benson et al. 1997)

These greenhouse inoculations are considered to be severe tests of resistance since 1) the inoculum levels are high, 2) environmental conditions are controlled to favor the pathogen and 3) the root systems are contained. It is possible that some fir species showing intermediate resistance in greenhouse inoculation trials may display useful levels of resistance under field conditions.

Field Evaluations

In addition to needing information about *Phytophthora* root rot resistance under field conditions, a better understanding of the growth and Christmas tree quality of alternative fir species is needed before growers can confidently substitute them for Fraser fir on high *Phytophthora* hazard sites. Toward this end, three field studies (the Alternative Fir Species Field Trial Series) were established during the 1999 planting season and two additional field studies (the Fir Grafting Study) will be established this coming planting season.

Alternative Fir Species Field Trial Series

The objectives of this field trial series is to compare Fraser fir with four promising alternative fir species for:

- 1) field resistance to *Phytophthora* root rot and
- 2) growth and quality as Christmas trees in the mountains of North Carolina.

The experimental design of this test series employs appropriate randomization and replication to allow an effective statistical analysis of the data collected. This experimental design is:

- 3 Locations: Alleghany, Avery and Jackson Counties
- 2 Areas/Location: *Phytophthora* Infested & *Phytophthora* Free
- 5 Reps/Area/Location
- 4 Species: Canaan, Fraser, Nordmann & Turkish Fir
- 25 Trees/Species/Rep/Area/Location (5 x 5 tree block plot)
- 3,000 Study Trees
- 150 Korean Fir (due to a shortage, only included in 1 Rep/Area/Location)
- 3,150 Total Study Trees

Phytophthora Infested Area

Rep I		Rep II			
Nordmann	Canaan	Fraser	Korean		
Fraser	Turkish	Turkish	Nordmann	Canaan	
Turkish	Fraser	Canaan	Turkish	Fraser	Canaan
Canaan	Nordmann	Nordmann	Fraser	Turkish	Nordmann
Rep III		Rep IV		Rep V	

Phytophthora Free Area

Rep I		Rep II			
Fraser	Nordmann	Turkish	Canaan		
Turkish	Canaan	Turkish	Nordmann	Fraser	
Canaan	Fraser	Nordmann	Turkish	Fraser	Fraser
Nordmann	Turkish	Fraser	Canaan	Nordmann	Canaan
Rep III		Rep IV		Rep V	

Figure 3. Example of plot layout at one location of the Alternative Fir Species Field Trial Series.

Evaluating Alternative Fir Species for Phytophthora Root Rot Resistance - continued

A single location consists of two areas, one *Phytophthora* infested and one *Phytophthora* free (Figure 3). At a 5 x 5 ft. spacing, each area occupies less than 0.5 acre and contains 525 trees. These studies were each established cooperatively with growers (Figure 4) who have agreed to perform all necessary cultural practices. Each field study will be assessed annually. At a minimum, total height and a disease score (1 = healthy, 2 = chlorotic, 3 = necrotic, 4 = dead) will be recorded every year. USDA Christmas tree grades will be assessed in the final year before harvest. Other traits may also be assessed if deemed appropriate.

Fir Grafting Study

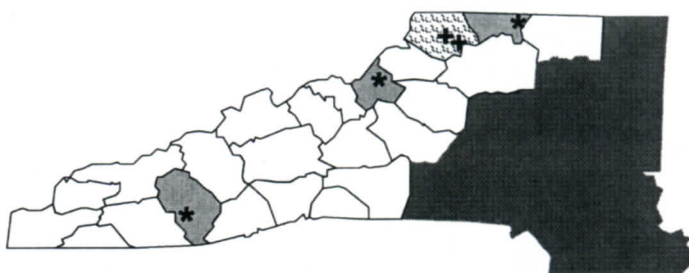
This study is being conducted collaboratively with Dr. Eric Hinesley, Department of Horticultural Sciences, to determine if Fraser fir can be grown as scion on *Phytophthora* resistant rootstock. Specifically, the objectives are to assess the following characteristics for Fraser fir scion grafted onto rootstock of alternative fir species:

- 1) grafting compatibility
- 2) field growth and Christmas tree quality and
- 3) *Phytophthora* resistance.

Fraser fir was grafted onto rootstock of each of the other five fir species as well as itself during March 1999. Grafting success has been excellent (well over 90%) and pre-plant measurements have been taken. These data will be analyzed and reported soon. The field study portion of this study will be established this planting season with the following experimental design:

2	Locations: <i>Phytophthora</i> Infested & <i>Phytophthora</i> Free
30	Reps/Location
6	Species: Canaan, Fraser, Korean, Momi, Nordmann and Turkish Fir
2	Types of Planting Stock: Grafts & Seedlings
720	Total Study Trees

Seedlings of each species will also be included in the field study. Comparing the performance of the seedlings of each species with that of the respective Fraser fir grafts will indicate the proportion of the potential resistance that the grafts obtained.



Study No.	County	Grower(s)	Farm
Alternative Fir Species Field Trial Series (*)			
9902	Alleghany	Rondal & Louise Farmer Margaret & Alfred Motsinger	Heritage Hill Farm Pine Shadows Farm
9903	Avery	Lynn Smith	Merlyn Farms
9904	Jackson	Wayne Moss	Norton Creek Farms
Fir Grafting Study (+)			
TBA	Ashe -- Clean	NCDA	Upper Mountain Research Stations
TBA	Ashe -- Infested	TBA	TBA

TBA = To be arranged.

Figure 4. Locations of established and planned fir species field trials in the mountains of North Carolina.

Conclusions

Results from greenhouse inoculations of several fir species have provided encouragement that *Phytophthora* resistant species exist. Testing is progressing to the field, not only to verify *Phytophthora* resistance, but also to evaluate Christmas tree quality. Additionally, the possibility of using *Phytophthora* resistant fir species as rootstock for Fraser fir Christmas trees is being assessed.

If none of the tested fir species proves to be suitable, it may be desirable to test others of the 40 to 50 fir species (*Abies* spp.) that occur worldwide. If an alternative fir species proves to be a suitable alternative to Fraser fir on high hazard *Phytophthora* sites, then additional testing may be initiated in the future to ascertain which geographic source performs best in the North Carolina mountains. Ultimately, a reliable supply of seeds adapted to the North Carolina mountains will need to be secured either by developing contacts in the fir species' native country or by establishing a local seed orchard.

Literature Cited

Benson, D.M., L.E. Hinesley, J. Frampton and K.C. Parker. 1997. Evaluation of six *Abies* spp. to *Phytophthora* root rot caused by *Phytophthora cinnamomi*. APS Biological and Cultural Tests. Vol. 13:57.

Chastagner, G.A., P.B. Hamm and K.L. Riley. 1999. Susceptibility of *Abies* species to *Phytophthora* root rot. (In preparation)

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