Evaluating Alternative Fir Species for Phytophthora Root Rot Resistance

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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 koraiensi Wilks.).

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).

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:

| Locations: Alleghany, Avery and Jackson Counties |
| 3
| Areas/Location: Phytophthora Infested & Phytophthora Free |
| 2
| Reps/Area/Location |
| 5
| Species: Canaan, Fraser, Nordmann & Turkish Fir |
| 4
| Trees/Species/Rep/Area/Location (5 x 5 tree block plot) |
| 25

Study Trees
| 3,000 |
| 150 |
| Total Study Trees |
| 3,150 |

Phytophthora Infested Area

<table>
<thead>
<tr>
<th>Rep I</th>
<th>Rep II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordmann</td>
<td>Canaan</td>
</tr>
<tr>
<td>Fraser</td>
<td>Korean</td>
</tr>
<tr>
<td>Turkish</td>
<td>Turkish</td>
</tr>
<tr>
<td>Nordmann</td>
<td>Canaan</td>
</tr>
<tr>
<td>Turkish</td>
<td>Fraser</td>
</tr>
<tr>
<td>Canaan</td>
<td>Nordmann</td>
</tr>
<tr>
<td>Nordmann</td>
<td>Fraser</td>
</tr>
<tr>
<td>Turkish</td>
<td>Nordmann</td>
</tr>
</tbody>
</table>

Phytophthora Free Area

<table>
<thead>
<tr>
<th>Rep I</th>
<th>Rep II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraser</td>
<td>Nordmann</td>
</tr>
<tr>
<td>Turkish</td>
<td>Canaan</td>
</tr>
<tr>
<td>Nordmann</td>
<td>Fraser</td>
</tr>
<tr>
<td>Turkish</td>
<td>Canaan</td>
</tr>
<tr>
<td>Fraser</td>
<td>Nordmann</td>
</tr>
<tr>
<td>Canaan</td>
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<tr>
<td>Nordmann</td>
<td>Canaan</td>
</tr>
<tr>
<td>Turkish</td>
<td>Canaan</td>
</tr>
</tbody>
</table>

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. Limbs & Needles • Winter 1999

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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:

<table>
<thead>
<tr>
<th>Study No.</th>
<th>County</th>
<th>Grower(s)</th>
<th>Farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>9902</td>
<td>Allegheny</td>
<td>-Clean -Infested</td>
<td>Rondal &amp; Louise Farmer</td>
</tr>
<tr>
<td>9903</td>
<td>Avery</td>
<td>Lynn Smith</td>
<td>Merlyn Farms</td>
</tr>
<tr>
<td>9904</td>
<td>Jackson</td>
<td>Wayne Moss</td>
<td>Norton Creek Farms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternative Fir Species Field Trial Series (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9902 Allenhany -Clean -Infested</td>
</tr>
<tr>
<td>9903 Avery</td>
</tr>
<tr>
<td>9904 Jackson</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fir Grafting Study (+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBA</td>
</tr>
<tr>
<td>TBA</td>
</tr>
</tbody>
</table>

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