White Pine Blister Rust Resistance Research in Minnesota and Wisconsin

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Outline

• Moose Fence planting near Tofte, MN
• P327
• USFS ORSO seedling screening efforts
• Minnesota Tree Improvement Cooperative
Moose Fence planting

• Cliff and Isabelle Ahlgren of the QSWRF
• Late 1960’s cooperative agreement
  – QSWRF, USFS, UMN
• Create the largest eastern white pine disease garden experiment in the world.
• Established near Tofte, Minnesota on north shore of Lake Superior.
A Nursery for the Future

You are looking at a living experiment. These trees may hold a key to the future of our majestic eastern white pine.

Why is eastern white pine in danger of disappearing?

White pine in the Great Lakes forests are declining for several reasons: disease, deer browsing, fire suppression, and turn-of-the-century cutting all play a role. White pine blister rust, an exotic disease unwittingly introduced from Europe, is the main reason Minnesota white pine has declined.

How did blister rust travel from Europe to America?

The fungus, white pine blister rust, was a new disease in America, one to which trees had no natural immunity. The disease attacks native white pine trees was much the same as the effect of widespread logging of Native American peoples' forests.

Is there hope for white pine forests?

With blister rust now widespread, one strategy is to encourage white pine that is genetically resistant to the disease using this plantation.

A possible solution...

A 1917 white pine from a nursery of provenance and growing conditions was planted here. As the plant moves, scientists take cuttings and examine wood from the cones of healthy trees.

If the spore lands on a white pine, it grows down the needle into the branch of the tree. It lives and grows for a few years, eventually swelling all the circulation of water and nutrients, killing the branch.

We hope this “nursery for the future” will help perpetuate a majestic part of our natural heritage.
Figure 1. Location of mother tree regions
Tofte white pine blister rust study

* = Tofte Test Site
Tofte establishment

- 874 op families
- ~43,200 seedlings
- 1972 and 1974
- RCB design
  - 5 replications
  - 10 tree row plots
- Ribes interplanted
- 22 acres
- Fenced
Tofte 1984 results

<table>
<thead>
<tr>
<th></th>
<th>1972 Planting</th>
<th>1974 Planting</th>
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<tbody>
<tr>
<td>Survival</td>
<td>38%</td>
<td>41%</td>
</tr>
<tr>
<td>Non-infected</td>
<td>1.0%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

1. Non-infected or clean trees occur at a very low frequency, i.e. < 1.0%.

2. No data to support existence of MGR in sampled mother trees.
Tofte 1993 tagging trees

- 888 exceptional trees permanently tagged


- Collect scion and seed from best
Search for slow-rusting phenotypes
• Search for slow rusters is NOT a search for plodding forest geneticists

• Rather a search for a phenotype that appears to co-exist with the fungus
Tofte 2010 results

<table>
<thead>
<tr>
<th>Category</th>
<th># Alive</th>
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<tbody>
<tr>
<td>Orange tagged trees</td>
<td>674</td>
</tr>
<tr>
<td>Blue (poss. slow rusters)</td>
<td>346</td>
</tr>
<tr>
<td>Yellow (soon to die)</td>
<td>134</td>
</tr>
<tr>
<td>Total</td>
<td>1154</td>
</tr>
</tbody>
</table>

• After 38 years 2.6% of the trees are still alive

• 18 years after being tagged 75.9% of the exceptional trees are still alive.

• 52 slow rusting phenotypes collected and grafted
P327

- Single tree selection from Duluth, MN
- Selected by R. Patton
- Progeny perform well in nursery and greenhouse trials.
- Recently more extensive testing.
Time to % mortality by family

[Graph showing the time to different percentages of mortality (25%, 50%, 75%) for various open pollinated families (H 111, WI 352, P 312, P 327, P 30).]
P327 histology

Reaction that collapses mesophyll cells

Densely packed mycelium surrounding vascular bundle

Jurgens et al. 2003
P327 and occluded stomates

Fig. 2. Environmental scanning electron microscopy image of stomata of secondary needles of A, susceptible clone H111 (bar = 60 µm) and B, resistant clone P327 (bar = 60 µm). Notice the large opening to stomatal chamber and lack of wax occlusion in A and the complete wax occlusion of stomata in B. White circles provide outline of a stoma.

Smith et al 2006
USFS – ORSO Region 9

• Oconto River Seed Orchard

• Breeding and screening objectives
White pine seed orchard provides seed for Region 9
Clone bank and simulated open pollinated (SOP) test
February first year
November first year
May second year

Foliar symptoms; % seedlings with symptoms
May second year
% seedlings with cankers

August second year
Canker severity
Screening results

• Dosage effect with susceptible and resistant families.

• Identification of target spore level.

• Recently 4-5 new genotypes (out of 34 tested) as resistant or increased resistance.
Minnesota Tree Improvement Cooperative

- 14 full members
- 6 supporting members
- 5 native conifer spp
- White pine breeding arboretum
- Manage Moose Fence planting
- Cooperator seed orchards
- Breeding program
214 Tofte genotypes and 94 non-Tofte genotypes
6 grafted seed orchards totaling 14 acres among 4 cooperators
Summary

• No evidence for MGR found
• P327 has reliable resistance but other genotypes do too.
• Unknown if these mechanisms are the same or complimentary
• Rationale for large plantings
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