White Pine Blister Rust Infection and Mortality in Sugar Pine: results through age 15

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INTRODUCTION

White pine blister rust (WPBR) caused by the fungus *Cronartium ribicola* was introduced to western North America in 1910 (Mielke, 1943). Since that time, it has spread throughout much of the range of sugar pine (*Pinus lambertiana*), causing widespread mortality. A very low frequency of natural resistance has made the management of sugar pine difficult. Screening and breeding for WPBR resistance by the USDA Forest Service and USDI Bureau of Land Management began nearly 45 years ago. This cooperative program has yielded seed from families with varying levels and types of resistance, most notably a single dominant gene conferring immunity to most strains of WPBR. This major gene resistance (MGR) (Kinloch, et al., 1970) produces a hypersensitive reaction that prevents the disease from becoming established in the host tissue. The discovery of a strain of WPBR that is capable of overcoming MGR (Kinloch and Comstock, 1981) illustrates the danger of relying solely on a single gene mechanism for resistance. The availability of sugar pine stock with various single- and multi-gene WPBR resistance mechanisms, combined with the appropriate site choice and silvicultural treatments, may make sugar pine a viable choice for reforestation in areas where it was once an integral part of the ecosystem.

MATERIALS AND METHODS

- Six sites (see Table 1 & Figure 1).
- 53 families from open-pollinated, phenotypically resistant wild trees screened for WPBR resistance in the early 1970's; 6 with major gene resistance (MGR), 25 non-MGR families common across all 6 sites.
- 2 sets, 4 blocks/set, 10 seedlings/block.
- Randomized complete block design, 10 tree row-plots[1] at 8' x 8' spacing.
- Measured at 5, 10, and 15 years.
- Height, presence & location of infection, cause & severity of damage recorded.
- In 1996-97 at age 15, # of cankers/tree, and height of highest canker recorded.

[1]Poker planted in random non-contiguous single tree plots.

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Figure 1. Mature sugar pine producing cones

Figure 2. Locations of Sugar Pine Test Sites

Table 1. Test Site Topographic Data

	Elev. (Ft.)	Slope (%)	Aspect	Rust Hazard*
Boulder	3,750	10	West	Medium
Anchor	3,600	20	East	Medium
Rocky	3,200	35	North	High
Hayes	2,850	50	South	High
Jamison	2,800	20	South	Low
Poker	4,200	35	West	Medium

*Rust hazard based on infection in 50 sampled wild pines, and number of *Ribes* plants per acre on a 1/100th acre plot within these 50 trees.

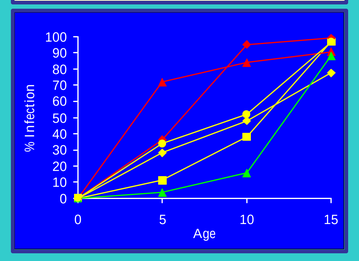
Figure 5. Severely forked tree as a result of the leader being killed

RESULTS

- Blister rust infection varied significantly by site at all ages, with the widest spread in site means being at age 10 (15.9 to 95.0%). (see Figure 3a)
- Infection percentage on all sites increased dramatically between age 10 and 15.
- Over all six sites 68.9% of all non-MGR trees were clean at age 5. This dropped to 48.3% by age 10 and to only 8.9% at age 15.
- Infection levels at age 15 for 6 families known to have MGR lie within the expected range of 50% on 5 of the 6 sites (see Figure 4a).
- Mean infection percentage at age 15 was 47.8 for MGR and 91.6% for non-MGR families with a range of 77.7 to 99.1%. (see Figures 3a & 4a)
- Mean number of cankers per tree on all living, infected, non-MGR trees varied widely by site from 2.3 to 11.9, although due to high mortality on some sites, these means are based on widely differing numbers of trees/site. (see Table 2)
- Mean height of the highest canker ranged from 59.8 to 144.5cm with 88% of all cankers below 2.0 meters.
- Mortality percentage of non-MGR families at age 15 ranged from 41.2 to 91.2%
- Mean mortality percentage at age 15 was 38.7 for MGR and 63.0% for non-MGR families respectively. (see Figures 3b & 4b)
- Some trees have survived because lateral branches took over after the leader was killed by a canker, resulting however, in severe forking. (see Figure 5 & 8)

25 Non-MGR Families Common to all 6 Sites

Figure 3a) Site Mean Infection Percent



6 MGR Families

Figure 4a) Site Mean Infection Percent

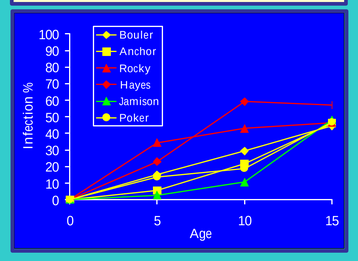


Figure 3b. Site Mean Mortality Percent

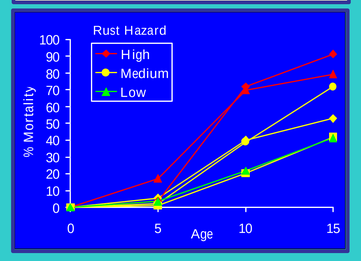


Figure 4b. Site Mean Mortality Percent

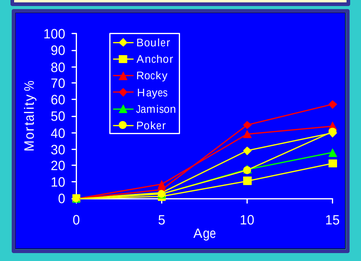


Table 2. Mean Height and #of Cankers by Site, based on non-MGR trees infected and alive at age 15

	Total # of Trees	# of Living Trees	Mean # Cankers per Tree	Mean Tree Height at age 15 (m)	Mean Highest Canker Ht. (m)	Highest Canker Ht. (m)
Boulder	435	243	2.3[e]	2.72[c]	0.60[d]	2.01
Anchor	507	481	6.6[c]	3.51[a]	1.45[a]	4.25
Rocky	187	109	3.4[e]	2.65[c]	0.62[d]	1.60
Hayes	82	74	11.9[a]	2.05[d]	1.31[b]	3.54
Jamison	485	408	5.0[d]	3.15[b]	1.04[c]	3.87
Poker	186	171	10.6[b]	3.29[ab]	0.98[b]	3.13

Groups with same letter not significantly different at a = 0.05

Figure 6. Initial infection site was on the branch, and the canker has grown into the main bole.

Figure 7. "Blight" reaction, where canker grew down the branch but was stopped at the main bole.

Figure 8. Tree with top killed by rust, with living uninfected lateral branches.

Figure 9. Branch canker that has killed the branch, but died before entering the main bole of the tree.

DISCUSSIONS AND CONCLUSIONS

- It is encouraging that except for the Hayes and Rocky plantations (which had "high" hazard ratings), mortality % is much lower than infection % and to date, there is no evidence of the presence of a virulent strain of rust on these sites.
- At young ages, repeated pruning of lower branches could be effective in reducing the probability of an infection on a branch becoming lethal. Pruning may be essential for providing adequate sugar pine stocking on higher hazard sites.
- On sites of comparable rust hazard rating, without pruning approximately 50% of the trees in MGR families would be expected to remain uninfected, while only 25% or less of the trees in the non-MGR families would be expected to remain uninfected.
- A recent visit to 4 of the 6 sites showed little new infection or recent mortality. The potential impacts of future infections higher in the crown will be smaller, and resistance mechanisms such as bark reaction and tolerance are operating.
- The viability of planting sugar pine in southwest Oregon will depend on several factors, including rust hazard, effectiveness of silvicultural treatments, type and durability of resistance, and the development of virulence in the rust population.

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