FUSIFORM RUST RESISTANCE OF CENTRAL AMERICAN AND MEXICAN PINE SPECIES COMPARED WITH LOBLOLLY AND SLASH PINES

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Abstract:--Seedlings of five Central American and Mexican pine species and loblolly *(Pinus taeda* L.) and slash *(Pinus elliottli* Engelm. var. *elliottii)* pines were tested for fusiform rust *(Cronartium quercuum* f sp. *fusiforme)* resistance at the USDA Forest Service Resistance Screening Center to determine the potential value of exotic species for improving rust resistance through hybridization with native species in the southeastern U.S..

The average infection of all species was 76%. *Pinus teocote* Schl. & Cham. was by far the most resistant with an infection rate of only 29% and the next best lot was *Pinus greggii* Engelm. (Valle Verde provenance) with an infection rate of 70%. *Pinus caribaea* Morelet var. *hondurensis* was the most susceptible species with 93% infection. "Resistant" (genetically improved) and "susceptible" slash pine lots showed 71% and 92% infection, respectively, indicating that genetic improvement of native species can result in infection rates as low or lower than that of the more resistant tropical pine species tested.

Pinus teocote is a good candidate for hybridization with native species due to its excellent rust resistance and it may offer potential to improve growth rate as well since it comes from lower latitudes than slash and loblolly. Under the right conditions, pines from more tropical regions will often outgrow temperate pines. It would be necessary to determine the cold adaptability in the southeastern U.S. of any hybrid between local species and tropical pines. The authors discuss the potential of temperate by tropical pine species hybrids.

Key Words: Tropical pines, *Pinus taeda, Pinus elliottii, Cronartium quercuum* f. sp. *fusiforme,* resistance screening, hybrid.

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INTRODUCTION

The CAMCORE (Central American and Mexican Coniferous Resources) Cooperative has made mother tree collections of tropical and subtropical pine species in Central America and Mexico since its formation in 1980 (Dvorak and Donahue 1992). The commercial value of some of these species was unknown in the beginning but some such as *Pinus tecunumanii* (Schw.) Eguiluz et Perry (Dvorak and Ross 1994), *Pinus chiapensis* L. (Dvorak et al. 1996a) and *Pinus greggii* (Dvorak et al. 1996b) are now being planted commercially or they are being considered for commercial use in the tropics and subtropics. It will become increasingly important to understand the degree of tolerance of these promising species to pests common to pine species in regions of large scale commercial plantations. For example, pitch canker *(Fusarium subglutinans* f. sp. *pini)* has recently been identified on *Pinus radiata* in California (Storer et al. 1994) and on *Pinus patula* in South Africa (Viljoen and Wingfield 1994). Little is known how this potentially serious disease will affect other tropical and subtropical pine species when planted as exotics.

Fusiform rust resistance of many pine species is not well studied either. In areas where the alternate host exists it is of value to know the rust resistance of exotic species in order to determine whether or not rust will be a serious problem. Furthermore, resistance information is needed to determine the potential value of a new species for hybridization with local species.

We were interested in determining the relative rust resistance of some Central American and Mexican pine species that have potential commercial value in the subtropics or in temperate regions as hybrids with local species in the southeastern U.S.. Most of these species will not likely be adapted to the climatic conditions in the southeastern U.S., specifically because they come from lower latitudes that do not experience the extremes in cold temperatures or extreme temperature change found here. Nonetheless, they may have value as hybrids with native pines if the local species can provide the adaptation to the regional climate and if the nonlocal species can convey to the hybrid some complementary characteristic such as faster growth, resistance to disease or desirable wood quality traits.

The objective of the study was to determine the relative rust resistance of seedlings of six Central American and Mexican pine species in comparison with three native species of commercial value in the southeastern U.S..

MATERIALS AND METHODS

Seed from 10 to 14 mother tree seed collections per Central American and Mexican pine species were mixed to form the seedlots used in the study. The species, provenance and some information at the area of origin can be seen in Table 1.

Table 1. Information on the areas of origin of the tropical and subtropical pine species screened for fusiform rust resistance.

PINE SPECIES	PROVENANCE	COUNTRY	ELEV. (m)	LAT.	LONG.	MEAN ANN. TEMP.C^0	ANN. PRECIP. (mm)
caribaea var *hond.*	Alamikamba	Nicaragua	30	13°34′	84°17′	27.3	2610
greggii	San Joaquin	Mexico	2350	20°56′	99°34′	14.0	1100
	Valle Verde	Mexico	1200	21°29′	99°12′	17.0	1400
herrarae	Guajolata	Mexico	2100	23°13′	105°11′	11.4	927
leiophylla	San Isidro	Mexico	2400	23°39′	105°02′	11.4	927
tecunumanii	San Jeronimo	Guatemala	1750	15°03′	90°18′	18.0	964
teocote	Maguayes	Mexico	2400	20°26′	98°30′	13.5	1341

Shortleaf pine ***(Pinus echinata*** Mill.) and ***Pinus herrarae*** Mart. did not have sufficient germinants to be included in the study. The local species checks are described below:

Lob Ark: is a rogued orchard mix made up of selections of loblolly pine ***(Pinus taeda)*** from local populations in Arkansas, Oklahoma, northern Louisiana and northeastern Texas although the majority of selections were made in Arkansas.

Lob NC: is a rogued orchard mix made up of selections from coastal NC.

Slash "Susceptible and Resistant": are standard check lots used at the USDA Forest Service Resistance Screening Center in Asheville, North Carolina that have been proven to be more "susceptible" and "resistant", respectively, to fusiform rust than wild stand collections of slash pine.

Seed were germinated and transplanted into Ray Leach Supercell containers. These containers were fertilized with one-half concentration of Miracle-Gro just prior to transplanting. Seedlings were then maintained at 70° F in the greenhouse until inoculation at six weeks of age. The test consisted of two runs, three trays per run, twenty trees per tray for a total of 120 trees per seedlot. Runs were inoculated one day apart. The inoculum was prepared by infecting three-week-old northern red oak seedlings with a bulk mix of aeciospores from both slash and loblolly sources from Louisiana, Mississippi, Alabama, Georgia and Florida. Basidiospores were harvested after three weeks incubation on the oaks. An inoculum solution was prepared at a density of 20,000 basidiospores per milliliter. Seedlings were preconditioned in a holding area for 24 hours, sprayed with inoculum, then

incubated in a chamber with controlled humidity (near 100%) and temperature (70° F) for 24 hours. Trees were then placed in the same holding area for another 24 hours then transported to a greenhouse.

Three weeks after inculation the test was fertilized with a full concentration of Miracle-Gro and placed on a six week fertilizing schedule. Seedlings were evaluated and percent galled scored at six months after inculation. Seed were sown in June 1996, inculations made in mid-August 1996 and evaluations were done in late January 1997.

Detailed procedures for fusiform rust screening can be found in the Resistance Screening Center Procedures (Knighten et al. 1988).

"Percent galled" was the only trait analyzed and reported on here. Analysis of variance was used to determine whether there were statistically significant differences among species/seed source lots, between runs and to detect run by seedlot interaction. The latter was tested to determine the repeatability of run results in terms of seed lot ranking. A correlation of seedlot ranking between runs was also conducted.

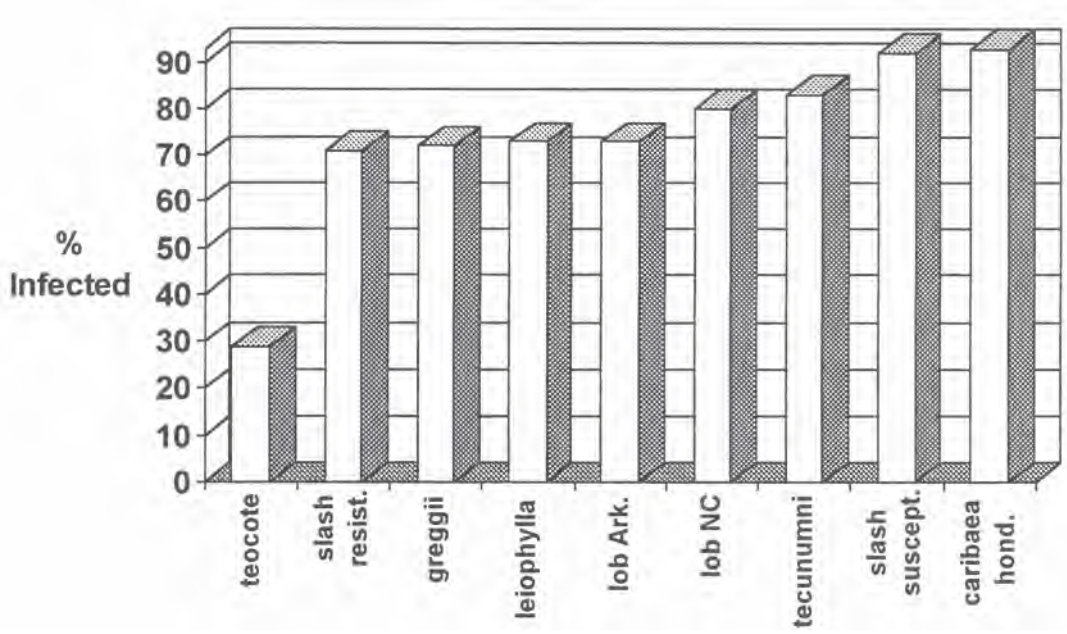
RESULTS AND DISCUSSION

Although the run x seed lot interaction was statistically significant at the 5% probability level, a high correlation of seed lot ranks between runs (r=.85) indicates that seedlots were consistent in their ranks for percent galled. When *Pinus leiophylla* Schl. et Cham. was dropped from the analysis the interaction term was no longer statistically significant and the correlation increased but only to r=.89. The overall fusiform rust infection level was high averaging 76% across all seedlots.

Pinus teocote had the lowest infection rate by far with only 29% infected (Figure 1) in spite of the high overall infection rate for all species. This species has morphological characteristics similar to shortleaf pine and may be evolutionarily related to it. Shortleaf pine is also highly resistant to fusiform rust and, when crossed with loblolly pine, conveys that resistance to the F1 hybrid progeny and to the backcrosses of the hybrid to loblolly (Kraus 1986). *Pinus teocote* would be a good candidate for hybridization with either loblolly or shortleaf pines. If it is otherwise adapted to the southeastern U.S. climate, it may confer good growth rate to either or both species and/or fusiform rust resistance to loblolly pine.

The next best non-improved species for fusiform rust resistance was *Pinus greggii* with 72% infection for the two provenances which were similar in their infection levels. The Valle Verde and San Joaquin provenances had 70% and 75% infection, respectively. These sources are from central Mexico and exhibit large differences in monoterpenes (Donahue et al. 1995), productivity (Dvorak et al. 1996b), and RAPD molecular markers (Furman 1997) to populations from northern Mexico. Because of these differences, trees from northern populations of *P. greggii* may be more resistant to fusiform rust than the southern provenances tested in this study. Both the northern and southern populations of *Pinus greggii*

Figure I. Fusiform rust infection levels of seedlings of five Central American and Mexican pines, loblolly and slash pines at the Resistance Screening Center.



may also be good candidates for hybridization with loblolly pine since crosses may convey fusiform rust and drought to the progeny. *Pinus greggii* has shown excellent growth rates and good adaptability in subtropical regions (Dvorak et al. 1996b).

The slash pine "resistant" check lot had as low an infection rate (7I%) of any species in this study except *Pinus teocote,* indicating the value of genetic selection for resistance in a species that is generally susceptible to fusiform rust. On the other hand, the "susceptible" slash pine lot had nearly as high an infection rate (92%) as the most susceptible species in the study which was *Pinus caribaea* var *hondurensis* with 93% infection. Tainter (I993) also found *Pinus caribaea* var *hondurensis* to be more susceptible to fusiform rust than slash pine. The infection rates were generally lower in Tainter's study but the species tested ranked similarly with *Pinus greggii,* "resistant" slash, "susceptible" slash and *Pinus caribaea* var *hondurensis* exhibiting infection rates of 53%, 58%, 75% and 88%, respectively.

Tainter (I993) tested some other Central American and Mexican pine species that may be of interest as exotics or as hybrids with our local pines. *Pinus patula* Schiede & Deppe in Schl. et Cham., *Pinus pseudostrobus* Lindl. and *Pinus oocarpa* Scheide had relatively low fusiform infection rates at 30%, 33% and 48%, respectively.

CABCORE members are currently conducting a number of exploratory hybrid crosses between Mexican and southeastern U.S. pines to find those that are viable. Preliminary results suggest that these crosses may be more successful when conducted in subtropical environments rather than temperate ones. Obviously, it would be necessary to field test any new hybrid since phenology patterns and other factors could result in different ranking of species for fusiform rust resistance than those observed in this study where all seedlings were

at a highly succulent state at the time of inoculation. Nonetheless, these results can be useful in terms of selecting some potentially good candidate species from the large number of exotic pine species available for hybridization with local pines if fusiform rust resistance is of great importance. It would also be of great value to test these exotic species for resistance to the Nantucket pine tip moth *(Rhyacionia frustrana)* and other pests of commercial importance in the southeastern U. S

Besides pest resistance, tolerance of tropical and subtropical pines to cold will be important in the choice of species to hybridize with local temperate species. Bost of the exotic pines in this study (with the exception of *Pinus caribaea)* can be found at high elevation where freezing temperatures occur (Perry 1991) suggesting a certain degree of cold tolerance but those areas usually do not have the wild swings in temperature that can occur in the southeastern U. S.. One strategy for achieving cold tolerance between a local temperate pine, such as loblolly, and a relatively cold intolerant exotic pine may be to hybridize the exotic pine with a more northerly provenance than the one in the area of interest. For example, cross a Virginia provenance of loblolly with *Pinus teocote* for testing in South Carolina or Georgia.

CONCLUSIONS

1. Pinus teocote was by far the most resistant species in the trial with a fusiform rust infection rate of only 29% while the other species had infection rates of 70% to 93%.

2. The most susceptible species was *Pinus caribaea* var *hondurensis* with 93% infection.

3. Selection for fusiform rust resistance in slash pine has been very effective at reducing infection levels. The "resistant" check had 71% infection while the "susceptible" check had 92% infection.

4. These results illustrate the importance of fusiform rust resistance screening of exotics for hybridization with local species or for planting in areas where the alternate host *(Quercus* spp.) of the rust exists and where the disease may be a problem in the future.

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LITERATURE CITED

Donahue, J. K., J. P. Perry, Jr. , A. E. Squillace, and S. Liu. 1995. Geographic variation in the stem-xylem terpene chemistry in native populations of *Pinus greggii* Engelm. Forest Genetics 2(4): 217-225.

Dvorak, W.S., J.K. Donahue and J.A. Vasquez. I996a. Provenance and progeny results for the tropical white pine, *Pinus chiapensis,* at five and eight years of age. New Forests I2:I25-I40

Dvorak, W.S., J.E. Kietzka and J.K. Donahue. I996b. Three-year survival and growth of provenances of *Pinus greggii* in the tropics and subtropics. For. Ecol. & Bgmt. 83:I23-131.

Dvorak, W.S. and K.D. Ross. I994. Three-year growth and stability of Honduran provenances and families of *Pinus tecunumanii.* For. Ecol. & Bgmt. 63:1-11.

Dvorak, W.S. and J.K. Donahue. 1992. Twelve year review of the CABCORE Cooperative: 1980-I992. College of Forest Resources, North Carolina State University. 93 pp.

Furman, B.J. I997. Phylogenetically informative markers as diagnostic tools to identify species, hybrids and introgression in Central American and Mexican pines. Ph. D. Thesis. College of Forest Resources, North Carolina State University, Raleligh, NC. 256 pp.

Knighten, J.L., C.H. Young, T.C. BcCartney and R.L. Anderson. 1988. Resistance Screening Center procedures manual: A step-by-step guide used in the operational screening of southern pines for resistance to fusiform rust. USDA Forest Service, Forest Pest Banagement, Region 8, Asheville, NC. 62 pp.

Kraus, J.F. 1986. Breeding shortleaf x loblolly pine hybrids for the development of fusiform rust-resistant loblolly pine. South. J. Appl. For. I0:195-197.

Perry, J.P. I991. The pines of Mexico and Central America. Timber Press, Inc., Portland, Oregon. 232 pp.

Storer, J., T.R. Gordon, D.L. Dallara, and D.I. Wood. I994. Pitch canker kills pines, spreads to new species and regions. California Agriculture 48:9-12.

Tainter, F.H. and R.L. Anderson. I993. Twenty-six new pine hosts of fusiform rust. Plant Disease 77(I):17-20.

Vilojen, A. and B.J. Wingfield. I994. First report of *Fusarium subglutinans* f sp. *pini* on pine seedlings in South Africa. Plant Disease 78(3): 309-312.