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Rust Resistant Loblolly Pines

A Comparison Of Seed Sources

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SUMMARY

The resistance to fusiform rust of loblolly pine seedlings from five different rust-resistant seed sources was compared in a green house inoculation test. Seed sources in the test were: 1) Livingston Parish rust resistant loblolly; 2) two forest industry rust resistant orchards; 3) a clonal and a seedling seed orchard from the Georgia Forestry Commission - USDA Forest Service (GFC-USFS) rust resistance program; and 4) a control of improved loblolly from a first generation production orchard. In a very severe rust test, the most resistant seedlings (61 percent rust free) were from the GFC-USFS seedling orchard. Both the Livingston Parish seedlings and those from the GFC-USFS clonal orchard had significant resistance at 44 percent rust free. One forest industry orchard was intermediate in resistance (34 percent rust free), whereas the second industry orchard was not significantly different from the production orchard controls, with 19 and 13 percent of the seedlings rust free, respectively.

The results indicated that the seedlings from the GFC-USFS orchard are among the most rust resistant currently available. The broad genetic base of this orchard should provide useful resistance on a variety of sites.

INTRODUCTION

Fusiform rust, caused by *Cronartium quercuum* (Berk.) Miyabe ex Shirai f. sp. *fusiforme,* is a limiting factor in the production of slash (*Pinus elliottii* var. *elliottii* Englem.) and loblolly (*P. taeda* L.) pines in much of the South (Powers et al., 1975). This disease is particularly damaging in a zone from South Carolina through Louisiana (Phelps, 1973), and Georgia suffers the greatest losses. The disease causes losses of $130 million annually (Anderson and Mistretta, 1982), and over a period of 10 to 15 years in the early life of plantations, numbers of infected trees may increase at a rate of 2 to 3 percent per year (Schmidt et al., 1974). Because of the impact of fusiform rust, private, state, and federal organizations have devoted considerable time and money to selecting and breeding of rust-resistant pines.

One of the largest of these efforts is the cooperative program by the Georgia Forestry Commisson and the USDA Forest Service (GFC-USFS). Work in this program began in the 1960's, and by 1975 enough individual trees with high rust resistance were available to begin establishment of a rust-resistant seed orchard. Selections for the orchard came from many sources, but most were from the GFC-USFS program itself. Each tree included in the orchard was a second-generation selection from 5- to 10-year-old progeny tests. These selections were all from families with better than average growth and yield, as well as rust resistance. Grafts were made from each selected tree and planted in the clonal rust resistance orchard (Fig. 1). Other orchard blocks in the GFC-USFS program were developed with a new technique that uses rust-free seedlings that have survived greenhouse inoculation tests as the orchard trees (Powers and Kraus, 1983) (Fig. 2).

Eight year old grafted rust-resistant loblolly pines in clonal orchard.

The research described here was designed to compare the rust resistance of loblolly pine seedlings grown from the GFC-USFS orchard seeds with that of seedlings from other rust resistant seed sources. Resistance was compared by greenhouse inoculation tests. Results of inoculation tests of this type have been closely correlated with field performance in several research studies (Dinus and Hare, 1974, Miller and Powers, 1983, Powers and Kraus, 1983). Included in the test were not only the seedlings produced from the GFC-USFS clonal and seedling seed orchard, but seedlings from most of the rust-resistant seed sources available to forest managers in the South today.

Good cone crop on rust resistant grafted loblolly pine.

MATERIALS AND METHODS

Bulk seed lots were obtained from six sources: (1) the second-generation seedling seed orchard (GFC-USFS) established with progeny of selected first-generation trees that remained rust-free after artificial inoculation tests; (2) a second-generation clonal orchard (GFC-USFS) composed of rust-resistant selections from first-generation progeny tests; (3) and (4) two forest industry first-generation rust-resistant orchards containing clones of most rust resistant selections available from a tree improvement cooperative; (5) a rogued first-generation clonal orchard of trees selected for multiple traits; and (6) the rust-resistant Livingston Parish geographic seed source, which has been widely planted in many parts of the South.

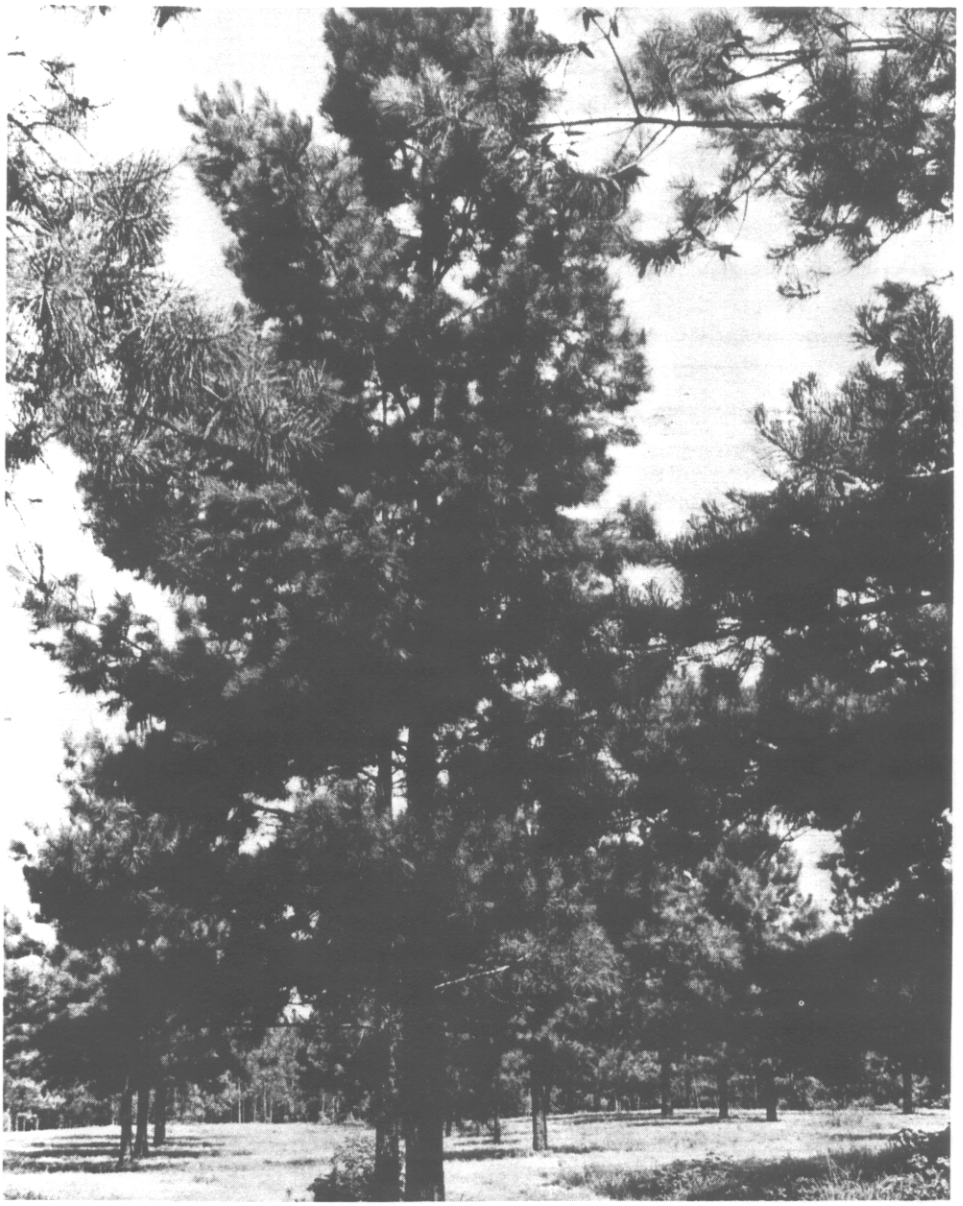
Seeds from each of the six sources were germinated, and seedlings were transplanted into plastic planting tubes measuring 4 x 21 cm, with one seedling per tube. The medium was a 5:4:1 mix of peat moss, vermiculite, and perlite. Basidiospore inoculum was produced by inoculating northern red oak *(Quercus rubra* L.) seedlings with a mass collection of aeciospores from rust galls in north-central

Table 1. Comparison of the rust resistance of seedlings from six loblolly pine seed sources.

Seed source	Percent rust free [a]
GFC-USFS (seedling orchard)	61 a
GFC-USFS (clonal orchard)	44 b
Livingston Parish	44 b
Rust-resistant industry orchard No. 1	34 c
Rust-resistant industry orchard No. 2	19 d
First-generation loblolly production orchard (commercial control)	13 d

[a] Values followed by the same letter do not differ significantly at the 0.05 level as determined by Duncan's multiple range test.

Thirteen year old loblolly pine derived from Texas rust-resistant source in seedling seed orchard at Baldwin State Forest.



Georgia. Four-week-old pine seedlings were inoculated by spraying them with a suspension containing 50,000 basidiospores per ml. Ninety-six seedlings per seed source were included in each of four replications, and a total of 2,304 seedlings were inoculated. The seedlings were grown in the greenhouse for 9 months before being examined for infection. Infection data were collected and the percentage of seedlings with typical galls was determined. Data were analyzed by a two-way analysis of variance, and means were separated according to Duncan's multiple range test (Hicks, 1964).

RESULTS

There were highly significant differences in resistance to fusiform rust among the six different seed sources of loblolly pine. The seed sources fell into four distinct resistance groups (Table 1). At the bottom with the lowest level of resistance were the commercial control, which was expected, and rust-resistant industry orchard No. 2, which was not expected. Seedlings from industry orchard No. 1 represented a step up in resistance with 34 percent of the seedlings rust free. Rust resistance of seedlings from Livingston Parish and from the GFC-USFS second-generation clonal orchard was even better, with 44 percent rust free. Alone at the top with 61 percent of the seedlings free of rust was the GFC-USFS second-generation seedling seed orchard.

Slash pine plantation adjacent to rust resistant orchard showing breakage at rust galls. Rust infection is over 85%.

DISCUSSION

The incidence of rust-free trees in this study ranged from a high of 61 percent to a low of 13 percent. A range of this magnitude is excellent for detecting differences in susceptibility to fusiform rust among various seed lots (Matthews, Miller, and Dwinell, 1978). Only 13 percent of the control seedlings remained free of rust, indicating that the test exposure to rust was quite severe -- more so than routine field exposure in plantations. Four of the five seed sources in this study were significantly more resistant than the commercial control seedlings. Clearly efforts to identify selections resistant to fusiform rust and to concentrate them into rust-resistant orchards are making progress. The resistance of seedlings from industry orchard No. 2, which was not significantly higher than the controls, was disappointing. Since our study, this orchard has been rogued of its less resistant clones, and industry orchard No. 1 is scheduled for roguing in the near future. As a result, resistance in future seed crops from both these orchards will be improved. As in the past, the Livingston Parish loblolly seedlings performed well with regard to rust resistance. These seedlings are recommended for use in the Gulf and South Atlantic Coastal Plain and have been widely planted on approximately a half-million acres across the South (Wells, 1985). They represent the most widely planted rust-resistant material at this time.

The performance of seedlings from the GFC-USFS seedling seed orchard is impressive and explainable. In addition to selection procedures that have been applied elsewhere, the trees in this orchard have survived rigorous artificial inoculation tests and an additional 10 years of screening by natural infection in the field. These trees have therefore been exposed to more intense selection than those in other rust-resistant orchards. In addition, these trees are half-sib progenies of almost all the known resistant clones in the South. The GFC-USFS seedling seed orchard therefore contains the broadest spectrum of rust-resistant material that is currently available.

The first commercial production from this orchard in 1984 was a mixture of seeds from both the clonal and the seedling seed orchards, so that the overall rust resistance should be excellent. Approximately one-half million seedlings were produced from that crop and made available to private landowners in Georgia. Each year the crop size increases and future production from this orchard, now in its 13th growing season, should bring continued improvement in rust resistance because there will be more pollen produced by the resistant trees within the orchard as time goes by.

Field plantings were made in 1980 of seedlings grown from a seed mix of 20 of the best selections in the clonal orchard for comparison with seedlings from a commercial first-generation loblolly production orchard. Fifth-year results show significantly more rust-free trees in the resistant mix (75 percent vs. 44 percent) (Powers and Stone, 1985). This increase in rust-free seedlings correlates well with the results of the artificial inoculations reported here. In addition, there was no significant difference in average heights. At age 5, height averaged 3.5 m for the resistant and 3.4 m for the production orchard controls. These early growth results cannot be considered definitive, but at least to this point there is no growth loss when resistant material is used. If the growth of the resistant trees continues at the present pace, and if infection levels as high as 85 to 95 percent continue to be observed on susceptible trees in areas of high rust hazard, plantings of these resistant seedlings will provide a tremendous saving for owners of forest land in Georgia and the South.

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