GEORGIA FOREST RESEARCH REPORT

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May, 1979

A SEED ORCHARD FOR RUST RESISTANT PINES-PROGRESS AND PROMISE

by
H. R. POWERS, JR.,
JOHN F. KRAUS,
AND
H. J. DUNCAN

RESEARCH DIVISION

GEORGIA FORESTRY COMMISSION

AUTHORS

H. R. Powers, Jr. is Chief Research Plant Pathologist with the Southeastern Forest Experiment Station at Athens, Georgia. He received a B.S. in Forestry at North Carolina State University, a M.F. in Forest Pathology from Duke University and a PH.D. in Plant Pathology from North Carolina State University. Before joining the staff of the Southeastern Station he worked on rust diseases of cereal crops with the Agricultural Research Service, USDA in Beltsville, Maryland. He is currently in charge of the Fusiform Rust Research and Development Program at Athens.

John F. Kraus is Principal Plant Geneticist, U.S. Forest Service, Southeastern Forest Experiment Station, Macon. He received a B.S. and M.S. degree from the University of Michigan. He earned his Ph.D. degree from the University of Minnesota. Dr. Kraus is presently Project Leader of the Breeding Southern Pines Work Unit at Macon, Ga.

H. J. Duncan is Senior Supervisory Technician with the Southeastern Forest Experiment Station at Athens, Georgia. He has served with the U.S. Forest Service for 29 years on a variety of disease projects. Among his responsibilities are all of the field activities relating to the establishment and maintenance of the rust resistant seed orchards and he is currently the senior technician on the staff of the Fusiform Rust Research and Development Program at Athens.

ON THE COVER

Top Photo—Rust resistance family of slash pine growing in high rust hazard area of Houston County, Georgia.
Bottom Photo—Susceptible slash pines heavily infested with Fusiform Rust in the same planting with resistant trees.

A SEED ORCHARD FOR RUST-RESISTANT PINES — PROGRESS AND PROMISE

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ABSTRACT

Increased resistance to fusiform rust is the most urgent need in improving today's planting stock of loblolly and slash pines. The Georgia Forestry Commission and the U.S. Forest Service, USDA, have recognized this problem, and are cooperating to establish one of the largest seed orchards for rust resistance. Some seed are already being produced in the 60 acre orchard, and full production will be underway in 4 to 5 years. Current estimates are that the seedlings produced from this orchard will cut infection levels in slash pine by approximately one half, and loblolly pine , by 40 percent.

INTRODUCTION

Pines that are resistant to fusiform rust for the tree farmers of Georgia and the South--that was the goal in 1975 when the Georgia Forestry Commission and the Southeastern Forest Experiment Station, USDA, Forest Service, set out on a cooperative effort to establish a 60-acre seed orchard for rust resistance. After 4 years we are about two-thirds of the way to that goal, a good place to summarize the progress and promise of the project.

The orchard contains slash (Pinus elliottii Engelm. var. elliottii) and loblolly (Pinus taeda L.) pines selected for high resistance to fusiform rust, caused by Cronartium fusiforme Hedgc. & Hunt ex. Cumm. Some of the 4-year-old grafted trees are already producing a few cones. Large numbers of resistant seedlings from this orchard's seeds will be produced in 4 to 5 years. When they are available they should do much to reduce the impact of fusiform rust, which is a very costly disease in Georgia.

THE PROBLEM

Fusiform rust is the number one disease of southern pines. It causes heavy damage from South Carolina to Louisiana. The Georgia Forestry Commission is especially interested in rust because surveys show that the highest incidence of infection is in Georgia (2). In central Georgia, for example, 42% of the 167 million slash pines in plantations have potentially lethal stem galls (4). In addition, it has been estimated that incidence of the disease is increasing at a rate of about 2 to 3% per year (5). Estimates of southwide losses to fusiform rust range from $50 to $100 million per year.

Loblolly and slash pines, the favorite trees for reforestation in the South, are highly susceptible to the disease. Seedlings are protected from rust in tree nurseries by spraying them frequently, but there is no practical way of protecting them once they have been planted in the field. The most promising way of reducing losses in plantations, therefore, is to plant seedlings that have resistance to the disease.

Fortunately, resistance to fusiform rust has been demonstrated in both slash (1) and loblolly (8) pines. In slash pine, the most common type of resistance has been found in individual, randomly located trees. Resistance in loblolly pine has been found not only in individual trees, but also in mass collections of seeds from specific geographic locations (6). Levels of resistance can be sharply increased by controlled crossing within species of trees with some resistance (3). This increase is especially important because crossing will occur when resistant trees are brought together in a seed orchard.

SELECTIONS

We have obtained resistant pine selections for the orchard from many sources. Those from Georgia originated from a cooperative program between the U.S. Forest Service and the Georgia Forestry Commission. Each tree from this program was a second-generation selection from 5- to 10-year-old progeny tests. Each was from a family with better than average growth and yield as well as resistance. Grafts were made from each selected tree and planted in rust resistance clone banks (Fig. 1). The clone bank of rust resistant slash pines was begun in 1968, and the loblolly pine clone bank 1 year later. The clone banks were intentionally established in high rust hazard areas. Since establishment in the field, less than 5% of the ramets in the slash pine clone bank have become infected with rust, while up to 95% of the trees in adjacent plantings have rust infection (Fig. 2).

When the ramets in these clone banks began to produce seed, we tested their wind-pollinated progency for rust resistance by artificial inoculation. We selected the best of these trees, based on the results of these tests, for the grafted orchard (Fig. 3). We also planted seedlings from these trees in the seedling seed orchard (Fig. 4).

Other rust resistant selections were from various tree improvement cooperatives, such as the North Carolina State University-Industry program. In these cases, we exchanged plant material to make the broadest possible use of the relatively few resistant clones that were available. We also selected resistant trees from bulk collections of loblolly pine from specific geographic areas in which some resistance to the disease had been observed. In all, some 60 different strains of loblolly pine, and 70 of splash pine, have been included in the orchard.

NEW CONCEPTS

We applied several new concepts establishing the orchard. Most seed orchards of improved pines in the South are grafted; that

FIGURE 1
Rust resistance slash pine clone bank in Houston County, Georgia

is, the scions of the selected trees are grafted onto root-stocks of nursery seedlings to form the seed-producing trees. In addition to this standard approach, we used the seedling seed orchard technique (7). The basic concept is to plant seedlings from either open or controlled pollinations of the best pine families. We planted them at a 15- by 5-foot spacing, much closer than the standard 30- by 30-feet in the grafted orchard. Since the trees are planted so close together, thinning must be ruthless to reach a final spacing of approzimately 30' x 30'. In our seedling seed orchard, 9 of every 10 trees will eventually be removed. We will leave as final crop trees only the very best of each family, in terms of rust resistance, and growth and yield.

To provide the most disease-resistant seedlings possible for our seedling seed orchard, we applied a totally new concept--the use of survivors of greenhouse inoculations. Rigorous artificial inoculations infected the most susceptible seedlings of each family in the seedling stage. We discarded the diseased seedlings, and planted the disease-free seedlings in the seed orchard. Since the orchard is in an area of heavy rust incidence, every tree that remains to produce seeds will have survived two stern tests--artificial inoculation as a seedling and natural infection in the field as a sapling. The results should be truly superior material for the final orchard.

PROMISING RESULTS

It is still too early to estimate precisely the resistance that seedlings from orchard seed will have, but there are some indications that the advantage will be large. As an example, consider the families in the oldest block of the seedling seed orchard. Artificial inoculation tests indicated that these 16 families had resistance ranging from excellent to intermediate. After 3 years of exposure to natural inoculation, infection levels on these families ranged from 2 to 47% (Table 1). Ten of the 16 families had 10% or less infection. Family SML-9 is a good example of high resistance. Only 2% of its members were

FIGURE 2
Severe rust infection in planting adjacent to rust resistance clone bank

PROMISING RESULTS

infected in the orchard, and the family has proven very resistant in other field plantings. Resistance of the six families with over 10% infection was ranked as moderate or intermediate after the artificial inoculations. Family 10-31, which has 47% infection in the field, was also ranked least resistant in the artificial inoculations. Thus, the results of our artificial inoculations are proving to be indicative of later field performance. We may include the very best one or two of the original 100 trees from family 10-31 as seed producers. If we do, our purpose will be to enlarge the genetic mixture in the orchard--this family has excellent form and growth.

In general, we have not sacrificed growth to obtain rust resistance. Height growth in the 4-year-old loblolly seedling seed orchard has been good. In all but one family, the average height of the 10 tallest trees in the family is more than 11 feet in 4 years (Table 1). Seed producers will be selected from these tallest members.

We plan to have a total of 60 acres of loblolly and slash pine in the completed orchard. At present, 39 acres have been planted. A few cones are already being produced on the 4-year-old grafted trees, but we estimate that full-scale production and sale of disease-resistant seedlings will begin in 4 to 5 years. During the next few years we will select the best possible mixture of seed-producing trees, and we will try to estimate as accurately as possible the level of resistance of bulked seed from the orchard.

We must emphasize one point--in these two pine species there is *no immunity* to fusiform rust. Even the most resistant of our pine families produce some individuals which are susceptible seedlings to this disease. At this time, and with our present selections, a resistant slash pine family will have about 35% susceptible seedlings, and a loblolly, about 45% susceptible seedlings. In a susceptible family, the figure is likely to be over 90%.

What happens when two resistant selections are crossed is most encouraging, however. In one of our studies with loblolly pine, two of the families listed in Table 1 were crossed, and the resulting progeny had less than 25% susceptible seedlings.This value was much lower than for either parent. However, until we are able to collect cones from the rust resistance orchard, with a fairly good assurance that the pollen also came from orchard trees, we will not be able to get a precise estimate of how well our new seedlings will do under field conditions.

To get some idea of field performance, for each species, we collected cones from the trees that were originally selected for inclu-

FIGURE 3 Four-year-old loblolly pine grafts in rust resistance seed orchard

TABLE 1 Rust infection (after 3 years) and height growth (after 4 years) of 16 loblolly families in the rust-resistance seedling seed orchard.

Family	Rust Infection	Average hieght of tallest 10 trees
	PERCENT	FEET
29-Rx1495-35	2	12.7
SML-9	2	11.4
11-9	6	11.8
TDR	6	13.0
TFS	6	13.5
42R	7	12.9
H.H.	7	7.4
11-20	7	11.5
1495-35	9	11.3
10-5	10	13.6
15-42	16	13.2
2318	19	13.1
T-605	21	13.9
T-601	25	13.9
29R	36	11.4
10-31	47	12.5

sion in our orchard. These seed were bulked to make a test mix for both loblolly and slash pine. However, it should be pointed out that these selections were often surrounded by susceptible trees which probably supplied pollen for the test seeds. Results of artificial inoculations with the test lots were:

Seed lot	Percent infected
Slash test mix	51
Slash control	93
Loblolly test mix	67
Loblolly control	90

The controls in this test were unimproved seedlings of these species, and results indicated a good reduction in infection, particularly for slash pine. When the selected trees are cross-pollinated by other resistant trees in the seed orchard, the gains in resistance should be even greater.

Our objective for this initial generation of rust resistant selections is to produce slash pine seedlings that will have less than half the infection of currently available planting stock, and loblolly pine seedlings that will have 55-60% the infection of current stock. We feel that these estimated gains are reasonable, and that by using these rust resistant seedlings in high disease hazard areas, a sizeable gain in pine production can be achieved.

FIGURE 4 Rows of four-year-old loblolly pines in rust resistance seedling seed orchard.

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A. Ray Shirley, Director
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Cost 1886.00
Quantity 6000

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