

Early Results of Mycorrhizal Inoculation of Pine in Puerto Rico

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Despite the presence of more than 500 native tree species in Puerto Rico, many efforts have been made to introduce pines. These attempts have been made because, compared to the native species, pine has a much wider accepted market and has the longer fiber necessary as a component of kraft papers. In addition pine produces higher yields on poor sites, and its silviculture and utilization are relatively simple. The latter two reasons alone would be sufficient on this island, where there is an abundance of degraded, abandoned agricultural land and a population almost completely lacking a woods-working background.

Although private introductions may have been attempted earlier, the first efforts of the U. S. Forest Service to introduce pine was in 1932. During the next two decades 93 studies were made, including 27 species listed, drawn from North America, Central America, the West Indies, Europe, and southeastern Asia. Trials were made on soil varying from heavy plastic clays to very light sandy loams. Elevations varied from less than 100 meters to more than 1000. Waterlogged, wet, moist, and dry soils were planted.

Seedlings were outplanted barerooted and in various types of containers. Planting was deep and shallow, and in deep shade to full sun. Plantations were left completely untended, cleaned completely, and cleaned in a circle around plants. Seedlings were fertilized in the nursery and in the field; fertilization was nitrogen only, minor elements, nitrogen-

phosphorous-potassium, and complete.

Although various treatments and species led to better development in the nursery, greater survival and longer persistence in the field, the ultimate result of all studies was complete failure. The only really encouraging note was that seedlings of *Pinus elliottii* Engelm. and *P. caribaea* Morelet treated in the nursery in 1950 with an inoculum of mycorrhizal fungi yielded outstanding seedlings. These failed in the field, but failure appeared to be clearly attributable to field handling rather than to a lack in the seedlings themselves.

INTRODUCTION OF MYCORRHIZAL FUNGI

Therefore, encouraged by reports of the success of the Trinidad Department of Forestry following mycorrhizal inoculation of pine seedlings, attention was concentrated beginning in 1955 on the introduction of mycorrhizal fungi. This was done in three ways: inoculating seedlings already established in the field, importing inoculated seedlings, and treating nursery bed with imported inoculum.

Inoculation of established seedlings

Seedlings of slash pine (*P. elliottii elliottii* Engelm.) were treated two years after outplanting with inoculum collected under stands of loblolly (*P. taeda* L.) and shortleaf (*P. echinata* Mill.) pine in North Carolina, U. S. A. The material was also kept separately as collected from the F horizon

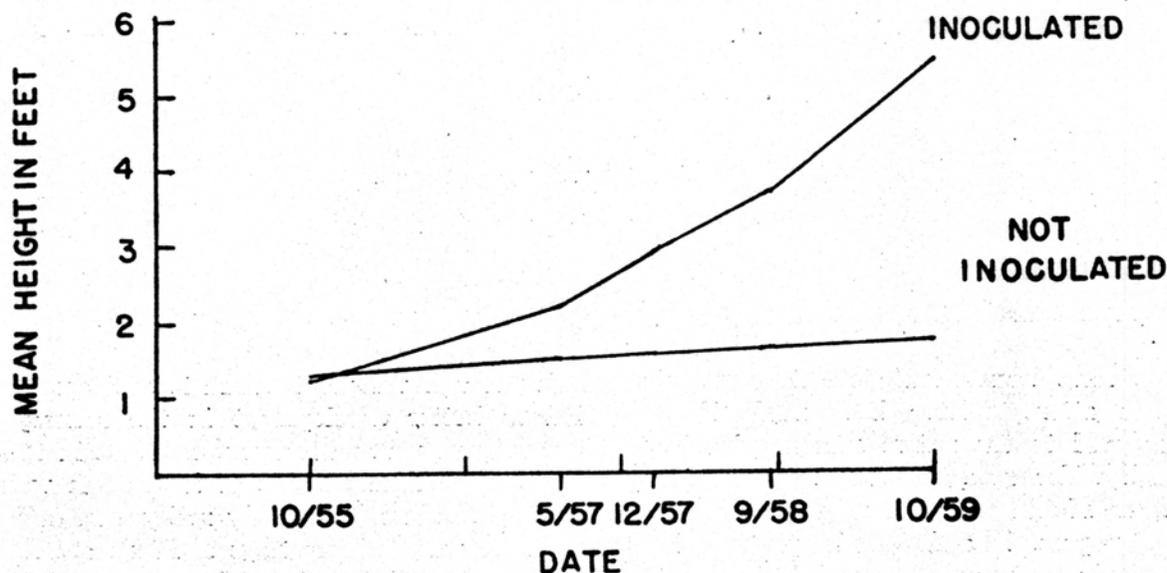


Figure 1. - Growth of established seedlings, 1955 - 1959. Basis: seedlings alive in 1959.

(fermented organic material) and the A₁ horizon (uppermost mineral soil including incorporated organic matter).

The soil in a circle with a 1-foot radius around each seedling to be treated was removed to a depth of four inches. A double-handful of inoculum was then thoroughly mixed with the soil and the mixture was replaced. From around half the checks the soil was removed and treated in the same way, except that no inoculum was added. The remaining check seedlings were left undisturbed.

Survival of the 20 inoculated seedlings was 85 percent; survival of the 22 seedlings not inoculated was only 36 percent. Of the surviving seedlings, those inoculated grew more than 13 times as much as those not inoculated (Figures 1 and 2).

That the improved growth was not due to the disturbance which accompanied the treatment is shown by the fact that for the disturbed controls the 1959 height was only 20 percent greater than the 1955 height, but the undisturbed controls grew 70 percent during the same period.

Differences correlated with overstory species and soil horizon of inoculum did not approach statistical significance.

Planting imported seedlings

In 1958 one-year-old seedlings of slash and loblolly pines were flown in from Mississippi, U.S.A., and outplanted at seven widely scattered locations.

Survival and growth have been satisfactory (Table 1 and Figure 3). Field inspection three months after planting showed mycorrhizae to be present on the roots of virtually all surviving seedlings.¹

Inoculation in seedbed

In 1959 inoculum collected¹ under a Virginia pine (*P. virginiana* Mill.) overstory in Maryland, U.S.A., was applied to sowings of *P. caribaea* Morelet seed from British Honduras and from Cuba.

^{1/} Dr. Edward Hacksaylo, Plant Physiologist, Forest Physiology Laboratory, U. S. Forest Service, Beltsville, Maryland.

Excellent seedlings were produced (Figure 4) and early survival following outplanting of potted seedlings averaged almost 98 percent.

SUMMARY

Because of their established market, utility, productivity, and relatively simple care needed many efforts have been made to introduce the true pines to Puerto Rico, an island on which no pines are indigenous.

Ninety-three studies varying in species, site, and cultural methods were unsuccessful, but indicated that mycorrhizal fungi might be a critical factor. Three studies were made to determine a practicable way of bringing in the fungi: Importing inoculated seedlings, applying imported inoculum to established seedlings, and applying imported inoculum to the nursery seedbed. All were successful, and healthy, vigorous pine seedlings are now establish on twenty different sites.

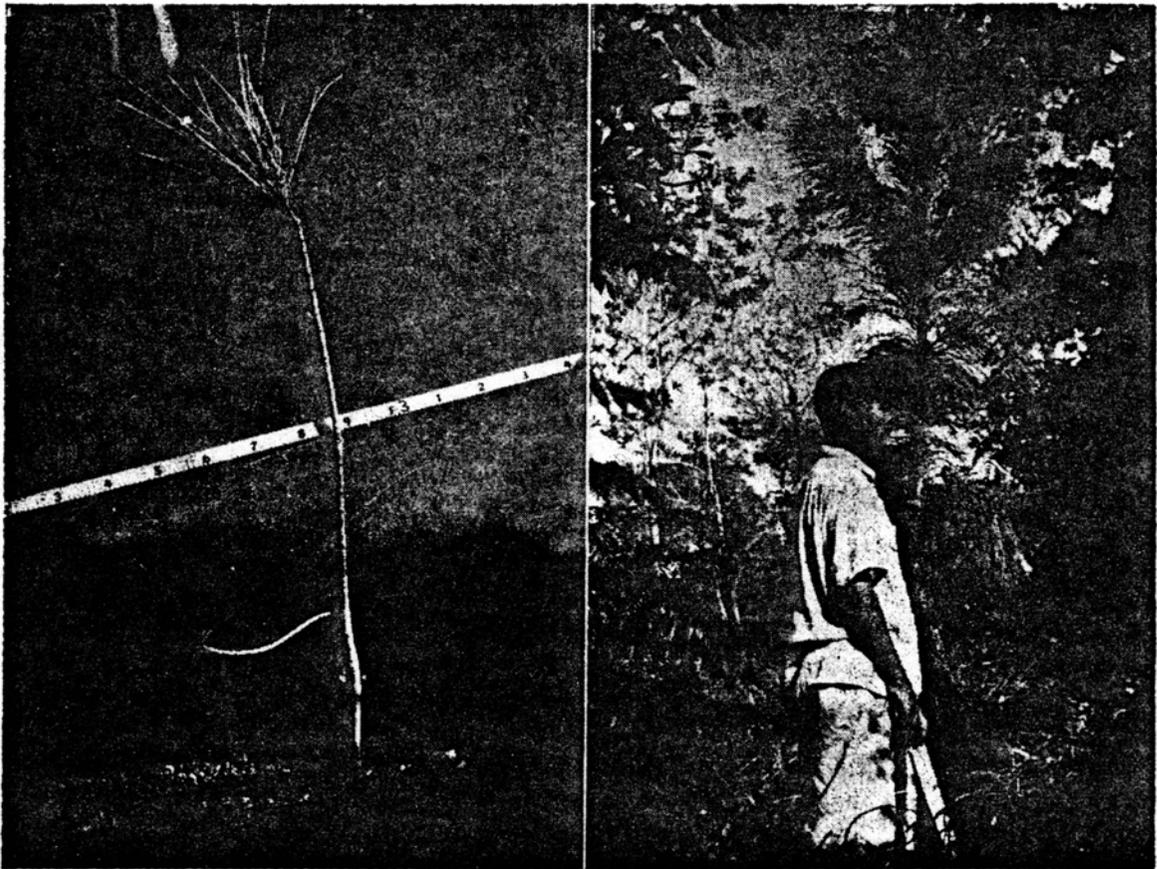
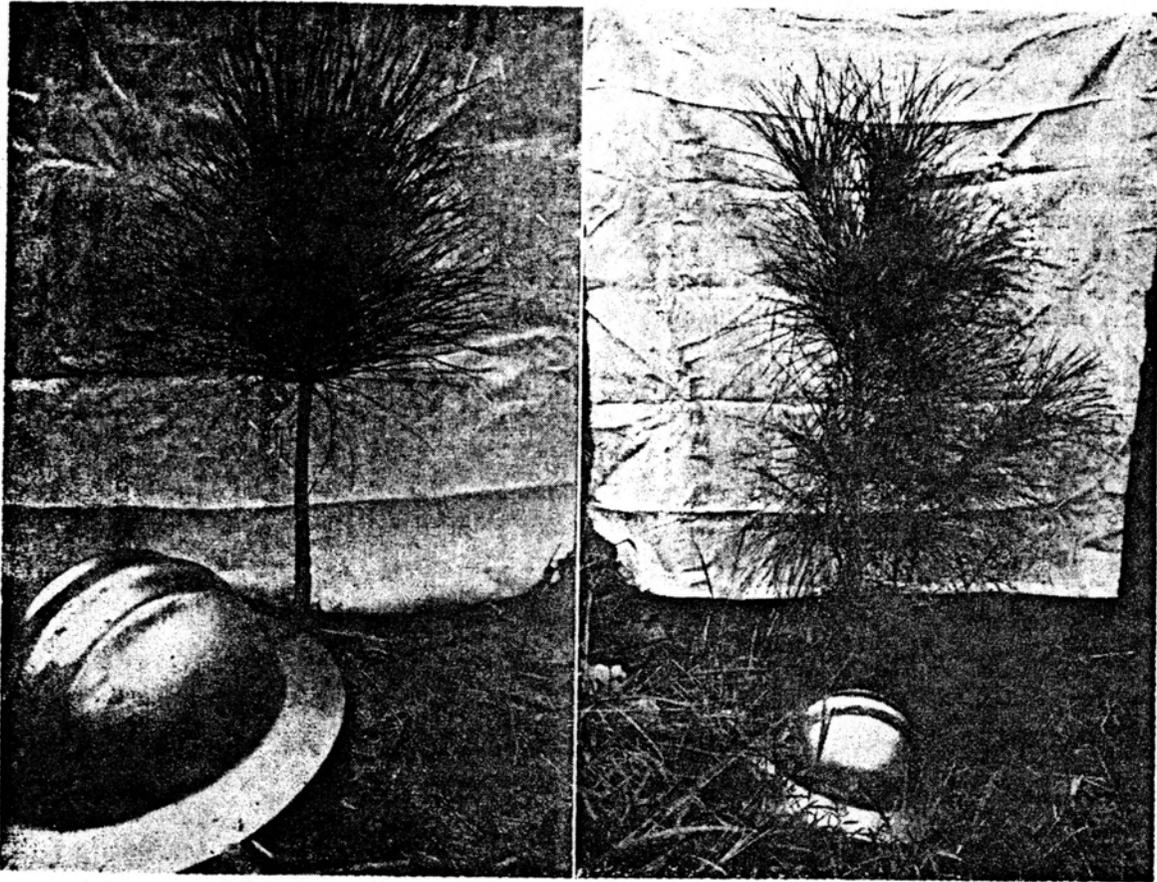


Figure 2. - Slash pine in October 1959. A. Not inoculated with mycorrhizae. B. Inoculated in October 1955.



A. Loblolly.

B. Slash

Figure 3. - Imported pines one year after outplanting.

List of Species of Pines Planted in Puerto Rico, 1932-1951

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|-------------------------------|----------------------|
| <i>Pinus ayacahuite</i> | <i>P. oocarpa</i> |
| <i>P. attenuata</i> | <i>P. patula</i> |
| <i>P. canariensis</i> | <i>P. pinaster</i> |
| <i>P. caribaea</i> | <i>P. pinea</i> |
| <i>P. densiflora</i> | <i>P. radiata</i> |
| <i>P. elliottii densa</i> | <i>P. rigida</i> |
| <i>P. elliottii elliottii</i> | <i>P. serotina</i> |
| <i>P. glabra</i> | <i>P. sylvestris</i> |
| <i>P. halepensis</i> | <i>P. taeda</i> |
| <i>P. insularis</i> | <i>P. thunbergii</i> |
| <i>P. longiflora</i> | <i>P. torreyana</i> |
| <i>P. merkusii</i> | <i>P. tropicalis</i> |
| <i>P. muricata</i> | <i>P. virginiana</i> |
| <i>P. occidentalis</i> | |

Table 1. — *Survival of Imported Seedlings in Plantations Kept Weeded*

Species	Survival percentage	
	Heavy soil	Light soil
	%	%
Slash	45	60
Loblolly	65	90

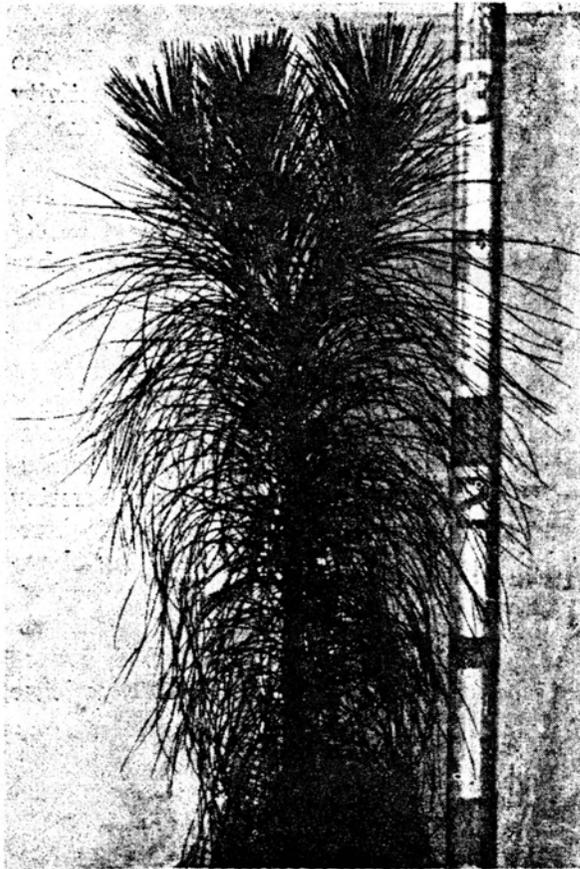


Figure 4. - *Pinus caribaea* inoculated with mycorrhizae in the seedbed. Seed source, British Honduras; age, 11 months.