# LETHAL ROOT TEMPERATURES OF 1-0 LOBLOLLY PINE SEEDLINGS

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This study determined the tolerance of root systems of loblolly pine (Pinus taeda L.) seedlings to immersion in hot baths and to heating simulating that which sometimes occurs in shipping bales.

## Procedure

Root immersion. --Experimental seedlings were obtained from two standard Forest Service bales of 2,000 seedlings. Random lots from the two bales were well mixed, graded, ax-pruned to uniform 8-inch root lengths, and tied into bundles of 20 plantable seedlings. The bundles were then immersed to root-collar depth in a constant-temperature water bath for the desired durations. Temperature of the bath did not vary more than ±0.25° C. for treatments which proved harmful. The roots were kept moist at all times.

Treatments were made on February 4-5, 1958. Seedlings were planted the next day in two randomized blocks on a silt loam with a moderate cover of bluestems (Andropogon spp.). Each treatment plot within each block consisted of a row of 10 seedlings. Survival was checked nine times between March and August and again in October.

Simulated heating of bales.--After several failures to induce natural heating of packaged seedlings, a clear 40-watt incandescent bulb, 11.5 inches long and 1 inch in diameter, was used as a heat source. The bulb was wrapped with several thicknesses of wet felt and then covered with a layer of moist sphagnum moss. The seedlings, graded and pruned as for root immersion, were mixed with additional moss and placed loosely around the bulb. This assemblage was wrappedina double thickness of black polyethylene film and sealed.

A thermocouple was placed among the seedling roots and the voltage supplying the light bulb regulated to raise the temperature slowly. When the desired temperature was reached, timing of the treatment was started. Temperature was controlled with a modified potentiometer (Thames and Ursic 1959) and maintained within ±1° C. during all runs.

Twenty seedlings were treated for 2 hours at each of 6 temperatures. Treatment was completed in a 2-day period and the seedlings planted in two randomized blocks on March 5.

In neither experiment did the treated seedlings appear different from the controls at the time of planting. Moreover, it was only after 60 to 90 days in the field that seedlings killed by the treatments could be distinguished from survivors. Kramer (1933) demonstrated that water absorption is not stopped by the death of the roots and that loblolly seedlings appeared normal 2 weeks or more after the roots were killed with heat. Delays of the magnitude encountered in the present study have not been reported. Lethal treatments became apparent with the advent of hot weather, however, and losses were minor after June 20, the date for survival comparisons in this paper.

## Results and Discussion

The data (table 1) indicate that safe limits for root immersion are 48° C. (118.4° F.) for 5 minutes and 46° C. (114.8° F.) for periods up to 2 hours.

The effect of increased duration was not only to reduce the lethal temperature but also to nullify variation in the tolerances of individual seedlings. The data suggest a relationship of the form:

$$Y = a + b_1X_1 + b_2X_1X_2$$

where $Y$ = probit transformations (Goulden 1952) of percent mortality

$X_1$ = temperature

$X_2$ = duration of immersion.

Although the data were inadequate for fitting and testing, this relationship (fig. 1) may be of interest to others working with the tolerance of plants to high temperature.

TABLE 1.--Mortality after immersion and simulated bale heating, June 1958

| Temperature (degrees C.) | Immersion[1] | | | Simulated bale heating, 120 minutes[2] |
|---|---|---|---|---|
| | 5 minutes | 30 minutes | 120 minutes | |
| | Percent | Percent | Percent | Percent |
| 20 | 5 | 0 | 0 | -- |
| 38 | -- | -- | -- | 10 |
| 42 | -- | 20 | 5 | 0 |
| 44 | -- | 5 | 10 | -- |
| 46 | 10 | 0 | 0 | 10 |
| 48 | 5 | 30 | 100 | -- |
| 50 | 25 | 95 | 100 | 5 |
| 52 | 80 | 100 | 100 | -- |
| 54 | 95 | 100 | 100 | 80 |
| 56 | 100 | 100 | -- | 100 |
| 58 | 100 | -- | -- | -- |
| 60 | 100 | -- | -- | -- |

[1] Mortality of unimmersed controls was 5 percent.
[2] Mortality of controls from unheated bales was 0 percent.

One implication of the considerable variation in heat tolerance is that carefully controlled hot-water immersion could be developed into a technique for evaluating the physiological condition of planting stock. Previous studies indicate that a plant continues to exist without the faintest sign of injury below the critical temperature and that death, attributable to coagulation of the protoplasm, is reached suddenly (Baker 1929). Shirley (1936) suggests that the thermal death point may be altered by an increased concentration of salts in the cell sap, which raises the coagulation point. Julander (1945) found that heat resistance increased with an increase in food reserves of grasses and further indicated that heat resistance is a measure of drought resistance.

The immersion data indicate that the relationship between the temperature which is lethal to all seedlings and the duration of treatment is logarithmic. This relationship is also apparent from data on temperatures lethal to southern pine needles (Nelson 1952),

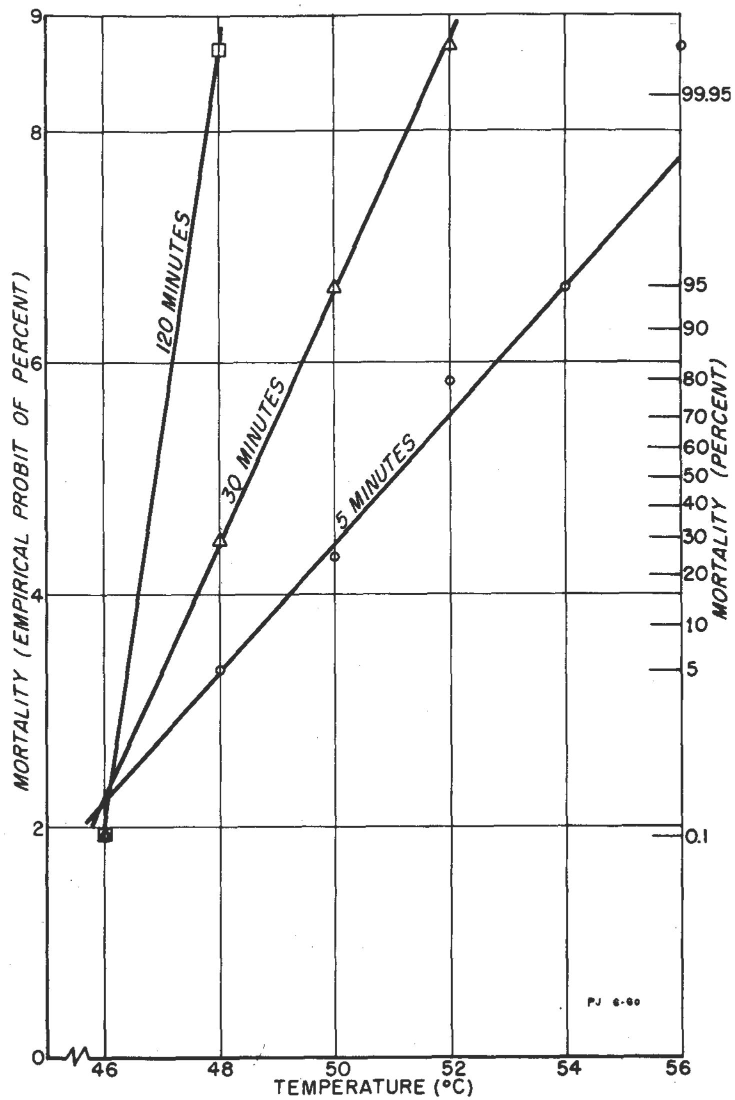


Figure 1.--Apparent relationship of empirical probits of percent mortality and temperature.

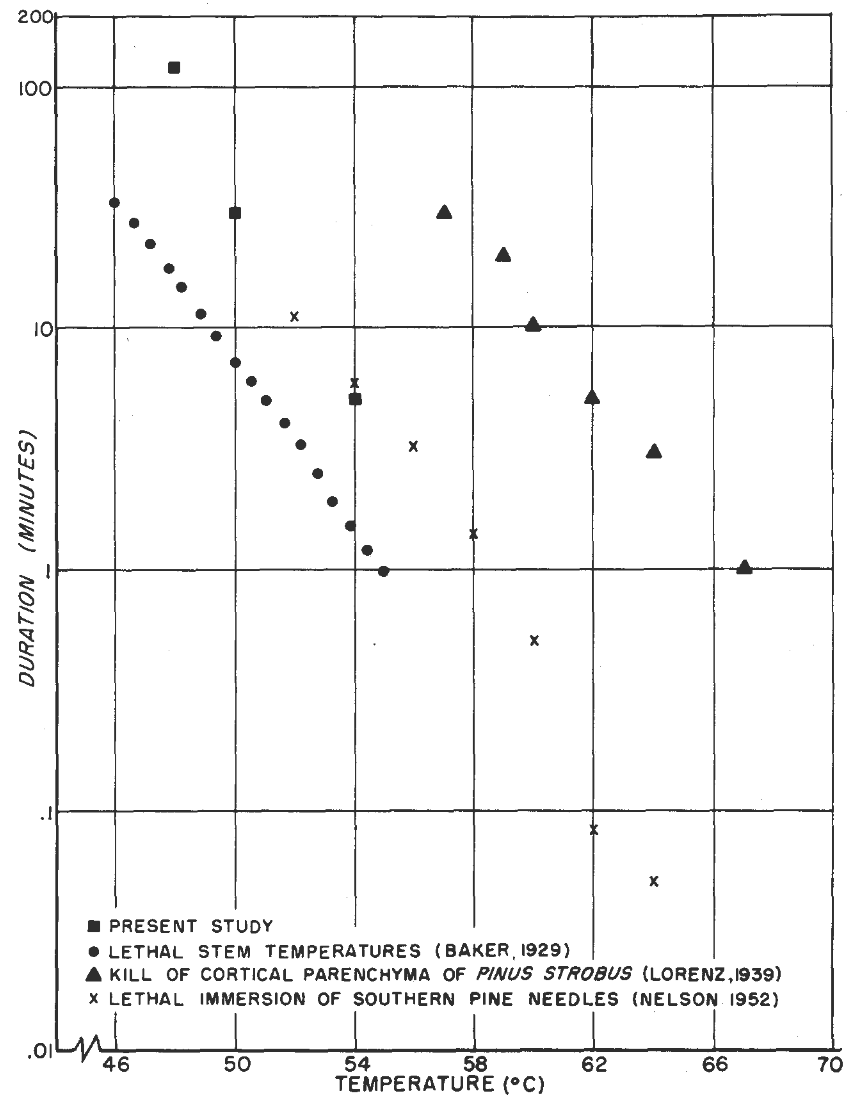


Figure 2.--Lethal root temperatures of 1-0 loblolly pine seedlings.

to cortical parenchyma cells (Lorenz 1939), and to conifer stems (as calculated by Baker 1929). These values are plotted in figure 2. Nelson's data, also based on hot-water immersion, appear to extend the relationship established in this study. Bigelow (1921) found a logarithmic relation in studies of temperatures lethal to bacteria; curves for different species of bacteria were parallel.

Parasitic nematodes are associated with the roots of all the major southern pines. Should it be found profitable to kill nematodes on infected seedlings to prevent contamination of planting sites, Christie's (1959) data indicate that root immersion would be effective. Results of the present study indicate safe limits for the treatment.

Seedlings in simulated bales withstood temperatures several degrees higher than those subjected to a water bath. The implication is that while plant tissues quickly attain the temperature of a water bath, the temperature of the surrounding air is not a reliable index to the temperature of plant tissues. Shirley (1936) also found that the lethal temperature was higher in air than in water--and higher in dry air than in moist air. The results in table 1 clearly show, however, that packaged loblolly stock which has heated in excess of $50^0$ C. should not be planted.

## Summary

This study attempted to determine the tolerance of root systems of 1 -0 loblolly pine seedlings to high temperatures.

Seedlings survived outplanting after their roots had been immersed for 5 minutes in water heated to $48^0$ C. Longer immersions or higher temperatures were very damaging. At 46° C. the seedlings withstood heating for periods up to 2 hours.

Baled seedlings heated by an incandescent bulb survived slightly higher temperatures, but indications were that stock is not worth planting if heated in excess of 50° C.

The relationship between lethal temperature and duration was found to be logarithmic. Data from other studies conform with this general relationship.

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