ARTIFICIAL LIGHTING FAILS TO STIMULATE HEIGHT GROWTH OF WHITE PINE SEEDLINGS IN NURSERY STUDIES

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During the 1957-60 period the Tennessee Valley Authority studied several methods of stimulating growth of white pine to reduce the time required to produce plantable seedlings. The methods included various artificial lighting treatments, fertilization, and different seeding times. At the nursery where the study was conducted, white pine is the only species requiring 2 years to attain plantable size. In 1961 the cost of raising white pine seedlings was $5 per thousand the first year and an additional $4 the second. Seedlings with secondary needles, well-developed terminal buds, and heights of at least 3 inches were classified as plantable. These criteria were consistent with general observations on minimum requirements for handling and outplanting white pine seedlings, although results of more recent tests indicate that 1-year-old white pine may be outplanted successfully.

Design

The studies were made on an average white pine nursery production bed at the Clinton Forest Nursery in eastern Tennessee. The test bed was 4 feet wide and 400 feet long; 10 power poles were spaced 40 feet apart along the edge (fig. 1). The bed was divided into 10 plots each 40 feet long; light sources were suspended from crossarms on the poles over the center of each plot. Each plot was subdivided into two subplots to correlate the effect of fertilizer with artificial light. This permitted five complete treatments with replication. A timing device controlled lights automatically in accordance with predetermined time schedules. Watering and shading procedures were those normally used for white pine.

Perceptible light readings extended an average of 11 feet beyond the centerline of the light source. Thus, each subplot contained control areas affected by normal daylight only, which at this location ranges from a maximum of 14 hours, 35 minutes on June 21 to 11 hours, 49 minutes on October 1, when seedling growth had stopped.

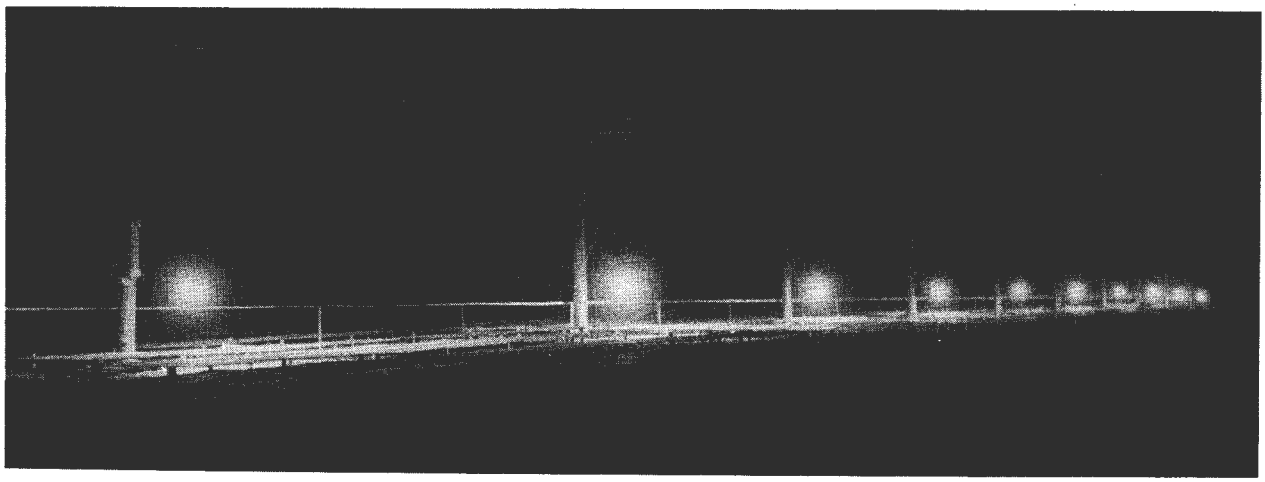

Figure 1.--Night view of white pine artificial lighting test at Clinton Forest Nursery.

Treatments

The 1957 test included five light treatments and two levels of fertilization. The light treatment periods were as follows:

1. 15-hour day, with artificial light before sunrise.
2. 17-hour day, with artificial light before sunrise and after sunset.
3. 15-hour interrupted day, with artificial light before sunrise and from midnight to 2 a.m.
4. 17-hour interrupted day, with artificial light before sunrise and after sunset and from midnight to 2 a.m.
5. Interrupted night, with artificial light between midnight and 2 a.m.

Fertilizer was applied at the normal rate for white pine--1,000 pounds of 10-22-12 per acre. This rate was doubled on half of each plot to determine whether extending the normal photoperiod would increase the ability of the seedlings to use additional soil nutrients. The light source was two 300-watt flood bulbs suspended 5 feet above the center of each plot. Each treatment was replicated, making a total of 10 plots. To determine which light intensity provided the best response, intensity readings were taken in foot-candles every two-tenths of a foot between the two central drill rows from the center to the extremities of each plot, and were averaged by 2-foot intervals. Height measurements and number of trees with secondary needles were also recorded in the same two rows, and averaged by 2-foot intervals.

The 1958 test was modified to take advantage of the most promising aspects of the 1957 test. Three photoperiods were involved:

1. 17 hours interrupted, with artificial light at sunset and from midnight to 2 a.m.
2. 16 hours interrupted, with artificial light at sunset, from 10:30 p.m. to midnight, and from 1:30 a.m. to 3 a.m.
3. 24 hours continuous light, with artificial light from sunset to sunrise.

To determine whether the date of starting artificial lighting had any effect on seedling development, 17-hour interrupted treatments were begun in May, June, and July. The other two treatments were begun in June. The five treatments were assigned to the 10 plots at random. No additional fertilizer was applied in 1958.

The 1959 test involved the effect of different spectrum lengths provided by colored lights. A comparison was also made of incandescent and fluorescent light. The five treatments were:

1. Incandescent, white.
2. Incandescent, blue.
3. Incandescent, red.
4. Flourescent, cool white.
5. Flourescent, daylight.

Plot layout was the same as in preceding years, and treatments were assigned at random. No additional fertilizer was used, and all lights were left on from dusk to dawn.

In 1960 the effects of the following light treatments on seedling development were measured:

1. Infrared.
2. Ultraviolet (mercury lamp).
3. Red flourescent.
4. Amber for midrange effect.
5. White incandescent as a reference tieback to previous years.

The five treatments were assigned to the 10 plots at random, and the lights were operated continuously from dusk to dawn. The seeding was done in late fall to promote early spring germination. In addition, a slowly available fertilizer, magnesium ammonium phosphate, was applied to half of each plot at the rate of 1,300 pounds per acre. Six-inch metal barriers were used between plots and between the two subplots within each plot to minimize leaching of fertilizer.

At the close of the 1960 tests, seedlings grown under each artificial light treatment and under normal daylight conditions were outplanted. Survival and growth were measured after two growing seasons.

Results

None of the treatments had an appreciable effect on the production of plantable seedlings. For all practical purposes, height growth was not changed. Development of secondary needles was stimulated by artificial light. When seedlings grown under artificial light were outplanted, their survival and growth were essentially the same as 1 -0 seedlings grown under normal daylight conditions.

Artificial lighting had a variable effect on height growth. Seedling heights ranged from 2.4 inches directly under the light to 2.8 inches 7 feet from the light source, where light intensity was 5 foot-candles (fig. 2). The average height of seedlings grown under normal daylight conditions was 2.7 inches. Fluorescent lights instead of incandescent ones, different color lights (red, blue, amber, and white), and infrared or ultraviolet (mercury) lamps had no appreciable effect on height growth.

All types of artificial illumination had a significant effect on the development of secondary needles. White, incandescent, filament-type bulbs were on the whole more effective than any of the other colors or types of bulbs tested. The proportion of seedlings with secondary needles increased as light intensity increased (fig. 2). There was no correlation between the photoperiod and production of secondary needles; however, extending the daylight to 24 hours stimulated earlier development of secondary needles.

Starting the artificial lighting treatment in May, June, or *July* made no difference in seedling development over the entire growing season. This probably indicates that the seedlings reach a peak performance, after which development remains rather stable.

Twice the normal amount of fertilizer adversely affected seedling height. Seedlings receiving normal applications averaged 0.2 inch taller than those receiving twice as much. Addition of slowly available fertilizer (magnesium ammonium phosphate) failed to stimulate either height growth or secondary needle development.

Fall planting did not result in the production of plantable seedlings in 1 year. The number of plantable seedlings was greatest under white incandescent lights and decreased progressively with red fluorescent, amber, infrared, and mercury.

Height and survival measurements two growing seasons after outplanting showed no significant difference between seedlings grown under artificial light and those grown under normal daylight conditions. The overall survival was 60 percent.

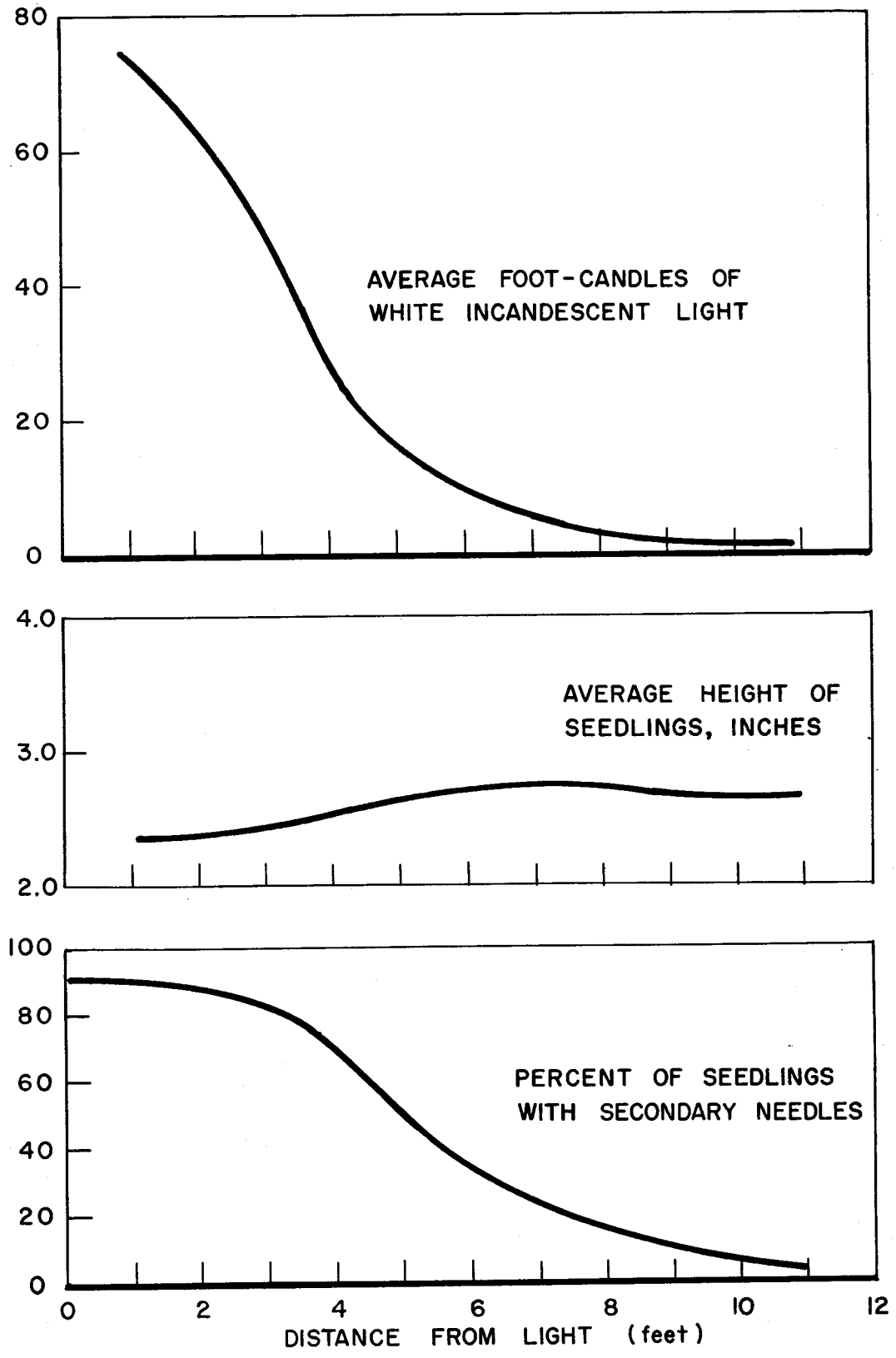

Figure 2.--White pine nursery production test of artificial lighting, 1957-60.