WHITE SPRUCE SEEDLINGS RESPOND TO DENSITY AND FERTILIZER TREATMENTS IN A PLASTIC GREENHOUSE

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Low seedling density and moderate fertilizer application in combination with an extended growing season under plastic produced large increases in growth. Germination and first year survival also may have benefited.

More intensive and more efficient methods of producing forest tree nursery stock are needed, especially in northern climates. A method that has proven successful in increasing both germination and seedling growth is being used extensively in several northern European countries. Simple structures covered with clear plastic are placed over seeded beds in early spring and allowed to remain until the fall. The system not only extends the growing season by stimulating early germination but also stimulates growth because of higher average soil and air temperature and humidity. It also permits more environmental control than is possible with unprotected beds, but less than could be furnished in a conventional greenhouse.

In 1967 I began a study at the Chittenden Nursery in northern Lower Michigan to determine if extending the growing season with plastic-covered structures might increase the quantity and improve the quality of seedlings of certain Lake States species (*1*). Results indicated that germination percent, first year nursery survival, and growth of jack pine, red pine, and white spruce were increased significantly over controls. Outplanting survival of white spruce grown under plastic was also superior to stock produced by standard methods. However, seedlings in the protected beds may have become so dense and growth so rapid that factors such as light and soil fertility had become limiting. To investigate this I began a second study to evaluate the effects of three seedbed densities and three levels of fertilizer application on white spruce seedlings grown under plastic.

Methods

Fertility of the nursery soil was first brought up to satisfactory levels of nitrogen, phosphorus, and potassium for white spruce nursery stock according to Wilde (*4*). Sphagnum peat moss was tilled into the soil to increase its nutrient and moisture-holding capacity, and the beds were then fumigated with methyl bromide. A greenhouse framework of the quonset type, measuring 16 by 60 feet, was erected over the prepared seedbed and covered with clear polyethylene plastic in early March. Seed from a National Forest seed production area in the Upper Peninsula of Michigan was stratified, dried, and mounted on a water soluble seed tape at spacings to obtain densities of 10, 20, and 30 seedlings per square foot. Germination percent in laboratory tests was about 90 percent. The tape was planted in late March.

Germination began during the second week of April. One month after germination a water soluble 15-30-15 fertilizer was applied at rates of 100, 300, and 600 pounds per acre to the various density treatments. Applications were repeated three times at monthly intervals. Electric heaters were provided to maintain a minimum temperature of about 45° F. Beds were watered with a sprinkler system and air circulation was provided by means of an exhaust fan and vent system (figure 1).

In September the plastic was removed to allow the seedlings to harden. The process of covering with plastic and fertilizing was repeated the next year to study seedling response for two growing seasons.

After the second growing season, seedlings were removed from several 1-square-foot sample plots of the different treatments to compare average stem length, stem diameter, dry weight of shoots and roots, and number of branches. Because mortality was not evenly distributed among the

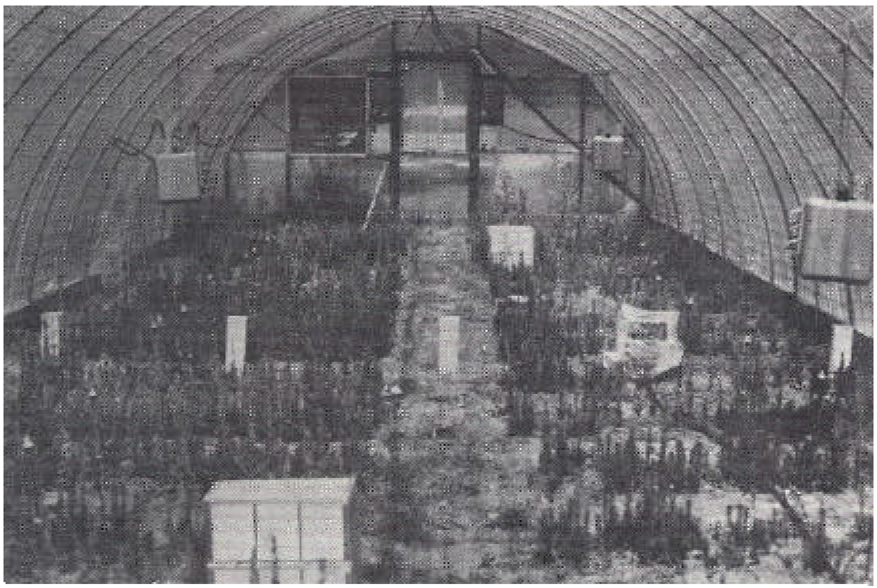

Figure 1.—*White spruce seedling plots during the second growing season. Note the electric heaters and exhaust fan.*

plots, only those plots with uniform survival were sampled. Average numbers of seedlings from these sample plots were 8, 14, and 21 seedlings per square foot for the low-, medium-, and high-density treatments. No statistical analysis of the data was attempted.

Results

Germination began about 2 weeks after sowing and was essentially complete in about 4 weeks. The seed tape did not appear to hinder germination in any way and was an effective means of obtaining the various spacings. Survival in the different plots at the end of the first growing season was variable, ranging from 10 to 61 percent of the sown seed with an average of about 40 percent. These differences appeared to be related to location in the greenhouse and were probably due to uneven temperature and soil moisture conditions, although some damping-off was evident. Little additional mortality occurred during the second season of growth. Air temperature in the greenhouse averaged 15° to 20° F higher than outside and reached a maximum of about 105° F. Soil temperatures in the greenhouse ranged from 82° F at a 6-inch depth to 100° F at the surface during the warmest days of the summer. The lowest temperatures were usually recorded near the edges of the greenhouse.

The low density and medium fertilizer treatment produced the greatest average stem length, stem diameter, and seedling dry weight (figure 2). This treatment also produced the largest individual seedling in the samples with a stem length of 56.5 cm, stem diameter of 1.1 cm, and dry weight of 21.3 grams. Standard deviations for the means of the two high fertilization-low density treatments (bracketed numbers in figure 2) indicate that seedlings having stem lengths of 40 to 45 cm, stem diameters of 0.8 cm, and dry weights of 15 to 16 grams would not be unusual. The heaviest fertilizer application (600 pounds per acre) gave no additional benefit and may even have been excessive. Generally, density appeared to have the greatest effect at the two highest fertilizer levels. The minimal growth response to the low fertilizer treatment suggests that 100 pounds per acre is not adequate to obtain a maximum growth response under these intensive conditions. The slight increase in stem length with increasing density at the low fertilizer level was unexpected and is difficult to explain in view of the opposite trend at the higher fertilizer levels. Density also affected branching, except at the lowest fertility level. As would be expected, the number of branches per seedling increased with decreasing density. Top-root ratio (oven-dry weight) increased slightly with an increase in density and fertilizer. The top-root ratio for all seedlings ranged from 2.08 to 2.81.

Discussion

Low seedling density and moderate fertilization in combination with an extended growing season under plastic can produce large increases in white spruce seedling growth. In this study germination and first year survival may also have benefited. Average survival of 40 percent of the sown seed after 1 year is about 10 percent greater than would be expected for white spruce in unprotected nursery beds according to Stoeckeler and Jones (*2*). The results also suggest that there is an optimum combination of density and fertility for producing maximum growth.

In general, these treatments produced 2-0 seedlings that exceeded Lake States planting stock specifications for 3-0 and 4-0 white spruce seedling and transplant stock (3). Growth could probably be further increased by extending the photoperiod with supplementary light and more

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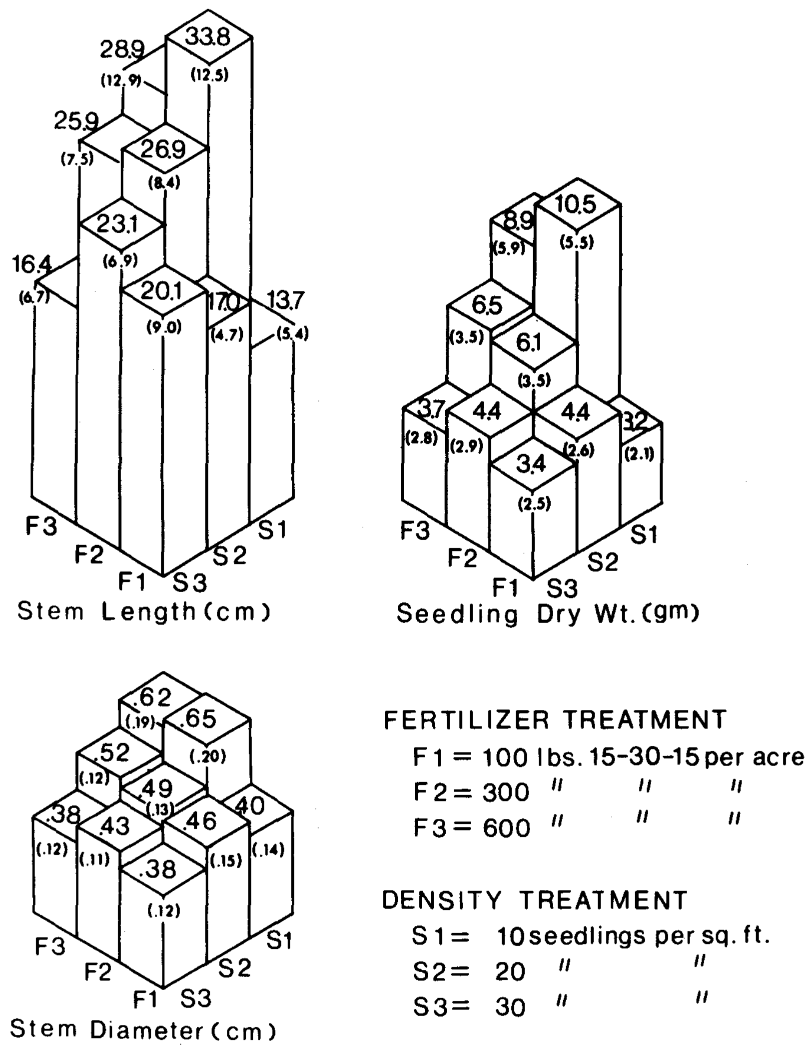

Figure 2.—*Average measurements of 2-0 white spruce seedlings grown in a plastic greenhouse under various density and fertilizer treatments. (Bracketed numbers are standard deviations of each mean.)*

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closely controlling the greenhouse environment. Whether the increased cost of these intensive measures would be offset by the shorter production times and increased survival and growth of the stock after field planting is not yet known.

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