Improvement of Stock Quality in the Forest Nursery

by J H. Stoeckeler 1/

The application of forest tree improvement will be largely through tree planting. Consequently much of the seed developed in seed production areas and seed orchards, or from special selections, hybrids, or other controlled pollinations will be used to grow nursery stock. It will be especially important, therefore, to use nursery practices that will produce the largest feasible proportion of high-quality planting stock.

It is possible, too, that seedlings of inherently high vigor can be selected in the nursery and thus provide a shortcut in forest tree improvement. Such selection must be based on comparison with other seedlings growing under similar uniform conditions. This implies good nursery management.

For these reasons there is given here a brief resume of nursery practices that are known to foster the production of high-quality planting stock. Included also is some evidence of the effectiveness of these practices.

Grading

The culling out of small, runty, infested, or otherwise defective stock in the nursery is in reality an early genetic rogueing of the plant material and invariably results in better field survival and growth and some reduction in the disease and insect potential. In a trial in Wisconsin (17) involving large, medium, and small *sizes* of 2-0 red pine, all from the same bed, the large trees had 12.4 percent better survival and 1.3 feet (35.1 percent) greater average height than the small size after 10 years in the field. The medium-sized trees had an advantage of 8.6 percent in survival and 1.0 foot (27.0 percent) in height over the small trees.

Even more contrasting results were noted in survival of 1-0 jack pine graded into 4 size classes (7). Plantings were made in the droughty mid-thirties. At end of the 13th year, field survivals were about 53, 35, 27, and 12 percent; for good, fair, poor, and cull classes respectively. The largest class had an advantage of 1.25 feet or 9.1 percent in average height over the cull group.

For white spruce, studies by Consolidated Water Power and Paper Company (3) revealed a 48.3 percent advantage in height growth (43 versus 29 inches) at the end of 6 years in the field for "super" seedlings representing the very best of stock, selected for outstanding growth in the nursery.

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Apparently inherent genetic vigor exhibits itself at a rather early stage, identifiable even in the nursery. hence, some grading in the nursery for quality, based on size, would seem to be warranted, Grading that removes the poorest 5 to 15 percent of seedling stock and 2 to 3 percent of the transplants would certainly seem to be a "must."

As seed orchards of superior or plus trees are established by rogueing of existing natural stands, and plantings are made of "elite" seed orchards of superior strains, it is believed that the percent of cull in nursery stock--now rather high in some of the run-of-the-mill collections--can be substantially reduced.

Age Classes of Stock

Age class of stock is a controlling factor in stock quality and field survival. Age class, of course, must be geared to species and to planting site conditions. Transplants have shown rather consistently better survival than seedlings, especially in white spruce (14) and to some extent in pine (6, 11, 17). The margin in favor of transplants over seedlings was 29 percent for white spruce and 20 percent for red pine in a series of tests run in Wisconsin and Michigan (17). In a number of plantations averaging 23 years of age, Rudolf (11) found average survival of 2-2 stock to be 60 percent compared to only 31 percent in 2-0 stock.

Contrast in survival by age classes is most likely to be large in drought years or on difficult sites. The age class of stock to be used should be dictated by long-range performance in the field and by the gains attained by older age classes or transplants when balanced against the additional costs.

Season of Sowing

Season of sowing has an effect on ultimate size of nursery stock. It can be adapted as a control technique on tree size in several ways. For instance, in one test of some 2-0 jack pine at Hugo Sauer Nursery at Rhinelander, Wis., fall-sown trees had an average fresh weight of 8.2 grams as compared with 5.3 grams per spring-sown tree seeded under comparable conditions; this was an increase of 54.7 percent (16). Second-year rod pine shows similar results.

On the other hand where soils are of a high fertility level or the growing season is tong, excessive top growth of jack pine may be prevented by seeding in June, thus in effect reducing the period of growth. This results in a 1½-0 age class which is in better balance then 2-0 stock from such nurseries and rather consistently gives better survival, especially for fall planting.

The adverse effect of poor top-root ratio on field survival has shown up repeatedly, especially in fall-planted 2-0 jack pine and 3-0 red and 3-0 white pine (17).

Fertilization

An extensive series of experiments on fertilization of stock in Lake States nurseries (16) led to these conclusion.

1. The most important value of fertilization in the nursery is the increase of plantable stock. This may be as much as 27 to 40 percent; such increases in percent of plantable stock are easily worth $400 to $G00 per acre of nursery.

2. Proper fertilization in the nursery gives a. slight but rather consistent improvement in survival of field planted stock; the advantage over unfertilized trees may be 5 to 10 percent.

3. Proper fertilization improves color, vigor, needle length, and bud length,

4. Fertilized trees shoved greater drought resistance than unfertilized stock.

5. Vigorous trees show more rapid juvenile growth.

Trees treated with balanced commercial fertilizers involving nitrogen, phosphorus, and potash usually show excellent; growth response when from 50 to 100 units of each are used per acre.

Composts and hardwood duff (16, 20) applied at around 2 0 to 30 tons per acre have resulted in excellent response by both coniferous and broad-leaved species.

Occasionally, dolomitic limestone is necessary to reduce soil acidity (13) and to correct deficiency of calcium and magnesium (1, 21).

Mycorrhizae

Lack of mycorrhizae has, on occasion, been a bottleneck in the production of good conifer stock, particularly in prairie soils. The mycorrhizae are beneficial fungi that aid in assimilation of phosphate, potash, nitrogen, and perhaps other nutrients.

In experiments run in the mid-1930's at Oakes and Towner, N. D., striking improvements were noted in beds of jack pine, Scotch pine, and spruces which had been inoculated with mycorrhizae either as pure cultures grown on boiled wheat or by means of mycorrhizae-rich soil brought in from an old established nursery. Our experience with the beneficial effect of mycorrhizae on growth of conifers in prairie soils was later verified by McComb (5) and Rosendahl (9). Our experience also indicated that the soil pH had to be slightly to moderately acid to permit good growth of the mycorrhizae. The soil was treated with at least 1/4 to 3/8 fluid ounce of sulphuric acid per square loot of seedbed applied in a 2-percent solution with water, or with at least 1/4 avoirdupois ounce of commercial grade sulphur per square foot worked into the top 4 inches of soil.

Seedbed Density

Seedbed density is an important factor in stock quality. Dense seeding tends toward spindly, undersized trees of poor caliper and poor root system. They survive poorly when field planted. They general practice in most publicly owned nurseries for trees scheduled for field planting is to seed so as to attain a density of around 40 trees per square foot for 3-0 pines and spruces and about 50 trees per square foot for 2-0 pines. When scheduled for transplanting, these species are grown at 65 to 75 per square foot. Even lower densities may be desirable, especially for 2-0 or 3-0 age classes scheduled for field planting.

Field survivals are often 10 to 25 percent better for stock grown at low (50) rather than at high (100-150) density. In fall-planted stock of 3-0 red pine, over-winter mortality was doubled by increasing seedbed density from 25 to 80 per square foot, i.e., mortality was 25 and 50 percent respectively for the two densities. High densities increase the top-root ratios of 3-0 red and white pine, producing trees poorly adapted to withstand over-winter as well as summer desiccation.

An increase in density of 3-U red pine from 33 to 101 trees per square foot resulted in a drop in green weight from 9.3 grams per seedling for the former to 5.0 for the latter; for 3-0 white pine grown at 26 and 81 trees per square foot respectively, the average green weight per plant dropped from 6.2 grams for the former to 3.5 grams for the latter (16). Stem caliper--an important factor in ability of recently planted trees to resist flattening or lodging by wind, rain, snow, or weeds--is also adversely affected by high densities.

Watering

Proper watering affects not only stock size but also, and more important, its field survival. Experiments by the Late States Forest. Experiment Station (12, 15) indicate that for second-year jack pine a moderate water supply involving addition of 2.25 inches of water in 3 applications as a supplement to 15.11 inches of precipitation that fell in the period June 1 to September 30 inclusive, gave better drought hardiness than trees receiving no irrigation, or those receiving 4.75 to 7.00 inches of irriga tion water.

The amount of water that nursery plants will require varies, of course, by nursery location, soil , tree species, age class, normality of rainfall, and its distribution,

Soil moisture content can be gauged by a number of methods, and among these the newly designed tensiometers used extensively in California show promise for use in irrigation control in forest nurseries where the tension is generally held below one-half atmosphere.

These tensiometers have a vacuum gauge dial and hence are more compact than the early experimental models developed in the late thirties, which used a U-tube mercury manometer.

Weed Control

Good control of weeds is an absolute essential in producing high quality nursery stock. This problem has been greatly simplified by the use of the right kind of cultivation equipment such as rotary hoes (16) and the use of selective herbicides such as mineral spirits (8, 14) and Dalapon. Pre-seeding treatments with herbicides such as allyl alcohol (18) and methyl bromide gas (4, 15) have been used to some extent for weed control; these same treatments also have some fungicidal value.

Root and Top Pruning

Root pruning or top pruning, alone or in combination, has been used as a means of producing nursery stock that is shorter, better-balanced, and more likely to survive the late fall and early spring desiccation.

In a series of experiments involving various depths and methods of root pruning and top pruning of seedbeds during; 1937-41 in several Wisconsin and Michigan nurseries, the best survival increases in field plantings were 16 and 23 percent respectively for fall-plantcd red and white pine. In the spring of the third year these had been root pruned horizontally at a depth of about 3 to 5 inches, and also vertically between each of the 10 drills in the seedbed.

Cone Quality and Ripeness

Since some nurserymen are charged with the responsibility for cone purchasing, the quality of conies deserves some mention. Cone quality, specifically size, can affect seed yield. In an experiment at Rhinelander, Wis., in 1938, red pine cones sorted into three sizes showed definitely that the small cones yielded less seed than medium- to large-sized cones, as noted in the table below.

Cone size	Average volume per cone cc	Total seeds per cone
Small	9.5	19.6
Medium	15.5	34.1
Large	18.1	43.1

In terms of number of seedlings produced, small cones wore also at a disadvantage as shown by the following table.

Volume of fresh cone	Seedlings produced per cone
cc.	No.
6	0
8	0.7
10	2.2
12	3.6
14	5.0
16	6.3
18	7.9
20	9.3

Eliason and Heit (2) found similar results in Scotch pine and concluded that cones of this species less than 1.5 inches long produced smaller seed and smaller seedlings than three larger grades of cones, ranging from 1.50 to 2.25 inches in length.

Cones, of course, must be ripe to realize their full seed value. Rudolf (10) found differential specific gravity a good means of determining ripeness of freshly collected red and white pine cones, using kerosene for the former and linseed oil for the latter.

Seed Treatment

Certain seed with embryo or seed-coat dormancy or both often germinate late or poorly, producing under-sized seedlings or under-stocked beds. Standard references on the subject (16, 19) give recommended treatments to assure prompt and complete germination.

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