SUGAR PINE SEEDLING SIZE--A REFLECTION OF SEED HANDLING?

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Until a few years ago seed procurement for tree nurseries was a relatively minor activity in California. But in 1960, a good seed year, the California Division of Forestry collected nearly 4 tons of tree seed valued at about $35,000 (4). The same year, the California Region of the U.S. Forest Service collected and purchased nearly 6 tons of seeds. This amount plus the inventory in storage was valued at $88,000 (2). Such expenditures probably will increase; therefore, steps to insure quality control are certainly justified.

Shortages of tree seed often plague the Regional nursery program; consequently, preservation of the quality of seeds in storage is important to maintain the supply of planting stock. A recent series of observations suggests (at least for sugar pine (Pinus lambertiana Dougl.)) that seed collection and storage methods may affect the vigor of planting stock.

The Placerville nursery, at a relatively new, low-elevation site, predominantly produces 1 -0 stock. Grading standards and optimum nursery practices are still under development. Yearling sugar pines at times have been too small for outplanting (fig. 1). Is this an unchangeable condition, or can cone and seed handling procedures affect the end product?

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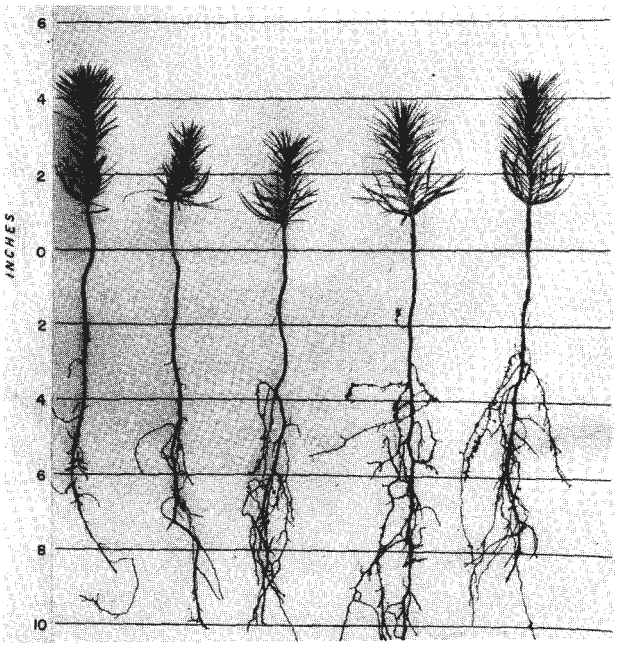

Figure 1.--These typical 1-year-old sugar pine seedlings were grown at the Placerville nursery and subjectively graded into size classes (large cull on left). These seedlings were sown on March 20, 1958, and lifted on March 2, 1959.

The observations reported here were not part of a designed experiment but were obtained from a series of development tests. [3] They strongly suggest that a little extra effort may reduce' the need to carry over sugar pine stock for 2 years. This aspect of cone and seed handling should be studied further.

Seedling Size and Age of Seeds

In the spring of 1961 four lots (with two rows for each lot) of stratified sugar pine seed were sown at the Placerville nursery in adjacent drill rows of the same seedbed. These seeds had been collected in various years by the U.S. Forest Service and stored under refrigeration at the Mt. Shasta nursery. Seed collected by the Forest Service was stored at the Mt. Shasta nursery at 34° F. until 1956, when the temperature was lowered to 23° F. Early in 1961, new seed storage facilities capable of maintaining 0° F. were installed. Thus, the seed lots endured different storage temperatures, depending upon the year of collection.

By August 1961, seedling sizes were uniform within all the beds (fig. 2). In April 1962, this uniformity was still apparent. In both months the visual observations were supplemented by the random lifting of sample transects and measurement of the size and weight of each seedling.

The 3-month-old seedlings steadily declined in seedling size with age of the seed (fig. 3). Top height, stem diameter (caliper), and fresh weight all decreased with age of the seed (table 1). Smaller seedlings were obtained in the 1954 and 1959 collections than in either of the 1960 collections, and seedlings of the 1954 lot were smallest. Similar size patterns were found among 1-year-old seedlings (table 2). Stem caliper reflects pine seedling weight quite closely at this nursery (1, see also footnote 2).

[3] Baron, F. J. Report on preliminary study to determine interrelations of seedling density and development in Placerville nursery seedbeds. (Unpublished prog. report on file at Pacific SW. Forest & Range Expt. Sta., Berkeley, Calif.).

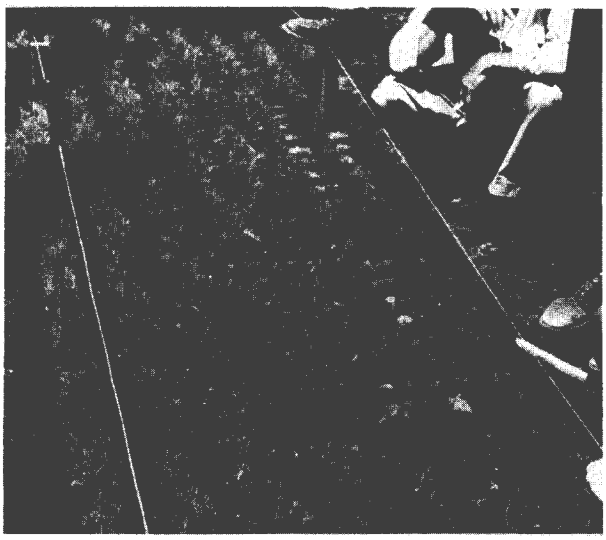

Figure 2.--These sugar pine seedlings were 3 months old when this view was taken on August 8, 1961. Starting on the left, the rows are numbered 1 to 8. Rows 1 and 2: 1960 seed, regular handling; rows 3 and 4: 1960 seed, special handling; rows 5 and 6: 1954 seed; and rows 7 and 8: 1959 seedling.

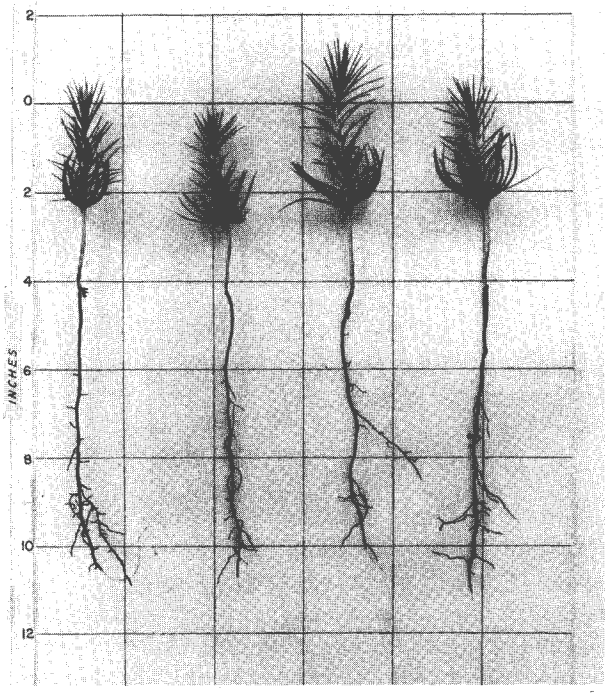

Figure 3.--Typical 3-month-old sugar pine seedlings grown in the same seedbed at Placerville nursery from four different sources of sugar pine seed. The seedlings are, left to right, 1959, 1954, 1960 "special," and 1960 "regular." The seedlings were sown in May 1961 and lifted in August 1961.

TABLE 1.--Measurement of 3-month-old sugar pine seedlings from four sources of seed grown in the same seedbed at Placerville nursery (averages of 50 seedlings)

Source	Top height	Stem diameter	Fresh weight
Regular handling:	*Inches*	*Inch*	*Ounces*
1954.....	3.2	0.061	1.31
1959.....	3.5	.066	1.39
1960.....	3.9	.073	1.80
Special handling:			
1960.....	4.3	.077	2.05

[1] At root collar a difference of 0.004 inch was significant (5 percent level).

TABLE 2.--Measurements of 1-year-old sugar pine seedlings from four sources of seed grown in the same seedbed at Placerville nursery, April 17, 1962 (averages of 100 seedlings)

Source	Top height	Stem diameter[1]	Fresh weight	Cull	Delay germination
Regular handling:	*Inches*	*Inch*	*Ounces*	*Percent*	*Percent*
1954.....	5.7	0.089	3.3	82	5.6
1959.....	5.7	.096	4.1	72	2.3
1960.....	6.1	.096	4.0	62	1.7
Special handling:					
1960 collection..	8.7	.106	5.2	24	1.6

[1] At root collar a difference of 0.008 inch was significant (5 percent level).

Seedling Size and Differences in Cone Handling

A striking contrast was noted between the two 1960 seed lots. "Regular handling" meant routine collection. No special effort was made to obtain the cones at optimal ripeness or to exert great care in seed extraction by solar heat. Noticeable mold developed on the drying cones. "Special handling" involved a simultaneous collection from trees in the same area. Cones were selected subjectively at optimum ripeness, and then air-dried carefully to insure adequate aeration and minimum mold development. All the cones from each tree and all the seeds from each cone were processed. No effort was made to segregate the larger cones or seeds.

Even when only 3 months old, seedlings from the "special" lot were larger than the "regular" lot seedlings (fig. 3). They were about the size of yearling sugar pine seedlings from an earlier study which used seed of unknown age and handling (fig. 1).

When 1 year old, the seedlings in each lot weighed nearly 2.5 times as much as the 3-month-old plants; their caliper had increased 1.3 times. At this age, the "special" seedlings were still the largest (fig. 4). A minimum caliper of 0.11 inch would have culled 60 to 80 percent of the 1-0 stock in three of the lots (table 2). Only the "special" stock had an acceptably low cull factor (24 percent). Samples of each lot, outplanted at different field locations, will supply further information on survival and growth.

Germination and Growth

Germination delays occurred in both years. In 1961, germination rates decreased with

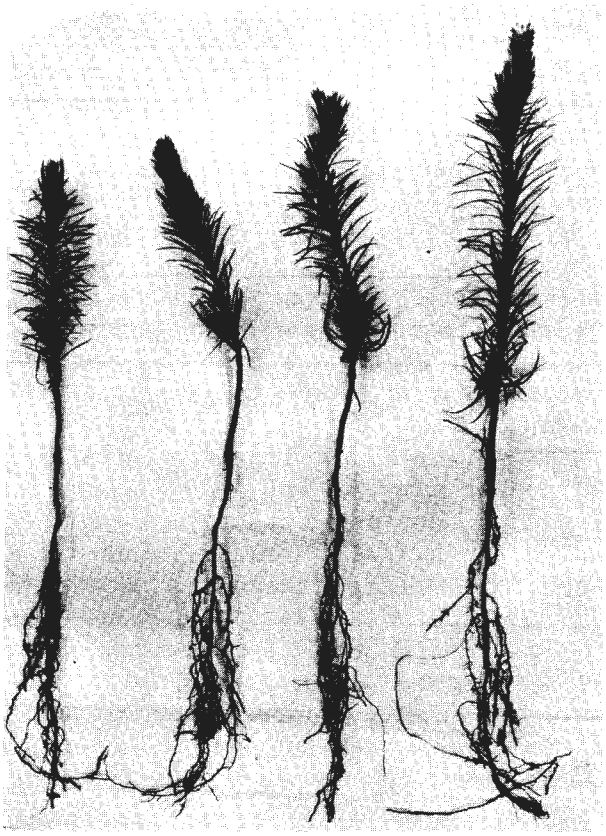

Figure 4.--These typical 1-year-old sugar pine seedlings were grown in the same seedbed at the Placerville nursery from four different sources of seed. The seedlings are, left to right, 1954, 1959, 1960 "regular," and 1960 "special." They were sown in May 1961 and lifted in April 1962.

The planting stock was 2-2 Norway spruce of German provenance (Petawawa Seedlot No. S-1723) supplied by the Southern Canada Power Company. Trees. were 6 to 12 inches tall and had well-developed root systems that were pruned before planting, when necessary, to about 9 inches. Bundles of trees were numbered in sequence when unpacked from crates and allotted at random to treatments; the stock was not graded, but most damaged or very small plants were discarded during planting.

The trees were lifted from the Drummondville Nursery on May 7. That evening they were heeled in at the planting site. Planting began on May 8 and was completed early in the afternoon of May 9. Planting was done with round-point shovels; careful supervision was exercised, and obviously bad planting was corrected. Different two-man crews planted blocks 1, 2, and 3, and all three crews planted block 4. The main difficulty was in planting on mounds and ridges, for they dried out fast and tended to break up when planted. Moreover, ridges were too small to accommodate the roots of the larger trees. With all methods the adverse effects of hot, dry weather increased during the planting period, and it appeared probable that survival would be lower in the blocks planted later.

In September 1957, 4 months after planting, mortality was recorded in 20 of the 24 rows, and some general observations were made on the condition of the trees. Weather records from a nearby military establishment indicated that precipitation during the 1957 growing season was appreciably greater than average. In October 1960, four growing seasons after planting, mortality was recorded in all 24 rows. All living trees were recorded, but no formal quality rating was attempted, although it was clear that there were differences.

Results

Mortality at the end of the first growing season was negligible (0.25 percent). In September the terminals of most mound- and ridge-planted trees were just above the tall grass or level with it. A few terminals of control and scalp trees were visible where the grass was shorter than average, but trees in furrows could be found only by parting the grass and searching carefully. The foliage of moundplanted trees was 'short and yellowish, and leaders were also short. All other trees, even those covered by grass, had healthy green foliage and fairly good leaders.

By 1960 the situation was greatly changed. Mound- and ridge-planted trees were obviously best in all respects, and furrow-planted trees were still completely hidden under the grass. Most trees on ridges and mounds were in excellent condition, while most trees in furrows appeared likely to succumb to smothering in a season or two. Pronounced differences in survival were also evident.

Survival percentages after four growing seasons (table 1) indicate that the rank of methods in descending order of survival was (1) mound, (2) ridge, (3) control, (4) scalp, (5) double furrow, and (6) single furrow. The decrease in survival from block 1 to block 4 is probably the cumulative result of dry weather during planting and was not unexpected; although other factors such as competition or soil moisture cannot be ruled out, they were not obvious.

TABLE 1.--Survival percentages of Norway spruce by blocks and methods four growing seasons after planting

Blocks	Methods						
	Mound	Ridge	Scalp	Control	Single furrow	Double furrow	Block averages
I	94	90	78	78	66	60	77.7
II	94	70	58	80	35	55	65.3
III	83	62	28	29	25	33	43.3
IV	68	48	33	23	16	28	36.0
Method averages	85	68	49	53	36	44	--

Analysis of variance of survival percentages (converted to angles) indicates that methods effects were statistically significant at the 1 percent level. Comparision of methods by critical differences permits the following generalization of the results:

(1) Mound planting is significantly better than all other methods.

(2) Ridge planting is significantly better than all methods except mound planting.

(3) Control is significantly better than single furrow but not better than scalp or double furrow.

(4) Scalp is significantly better than single furrow but not better than double furrow.

(5) Double furrow is not significantly better than single furrow.

Discussion and Conclusions

Of the six methods tested, only mound planting yielded acceptable survival after four growing seasons; trees planted by this method had grown more than those planted by other methods. Raising the planted trees in relation to competing vegetation apparently increases survival. The second best method, ridge planting, also raises the trees, although not as much as mound planting. Conversely, lowering the trees apparently decreases survival. Even the slight lowering involved in scalping may be sufficient to reduce survival, and the poorest method of the six, single furrow, is the one that lowers the trees most and reduces competition least.

Because survival has been the only criterion of success used, the furrow methods, and possibly also the scalp and control methods, appear better than they really are. Many of the trees surviving in the furrows in 1960 were almost certain to die from smothering in one or two seasons, whereas most surviving trees on mounds and ridges were well established and growing vigorously. Competition for light, moisture, and nutrients apparently was a less important factor in mortality than the effect of smothering by dead herbaceous vegetation that covers the trees in the fall and tends to remain in place the following spring. Vulnerability to smothering would be decreased by raising the trees and increased by lowering them. In addition, the larger and sturdier the tree, the more resistant it would be to smothering.

Mound planting was clearly the best and ridge planting a reasonably close second when it is realized that the planting stock was not particularly robust. However, mound planting is laborious and expensive, and when planting on sites similar to those used in this experiment, it would be best to plant on wider and higher ridges. Ridges 14 inches wide and 6 inches high should be as good as mounds and could be made by ploughing deeper and wider. If well-balanced 10- to 12-inch stock was used, chances of success would be excellent. Machine planting on such sites would not often be practical because they are rarely extensive, but reasonably good results might be obtained by planting large stock with a planter equipped to make scalps 18 inches wide and 1 inch deep. Removal of dead grass from trees in danger of smothering after the first and second growing seasons would further improve results.

Although planting methods that lower the trees in relation to ground level apparently should be avoided, it is important to recognize that raised planting ordinarily makes. trees susceptible to adverse effects later in life. Interesting information concerning the effects of raised planting on root development and development in general may be obtained by future observations in this experiment.

Summary

Six methods of planting 2-2 Norway spruce were tested on a site characterized by deep, rich, moist soil and a dense growth of herbaceous vegetation consisting of various grasses and clumps of thistles, goldenrod, and milkweed. Two of the six methods (mound and ridge) were used to elevate the planted trees above competing vegetation, three (scalp, single furrow, and double furrow) were used to reduce competition above and below ground, and one (control) was used to show the effects of normal competition.

After four seasons, survival and condition of planted trees were best in mound planting, and ridge planting was a reasonably close second.

Scalp and control planting were of doubtful value, and furrow planting was quite unsatisfactory. Evidently raising the planted trees in relation to the ground line significantly reduces mortality caused by competition and smothering, while lowering the trees below it increases losses.

For such sites planting of well-balanced 10- to 12-inch stock on ridges 14 inches wide and 6 inches high is recommended. Machine planting of similar stock in 18-inchwide scalps is thought to be a good possibility if dead grass is removed from the trees after the first and second growing seasons.

Acknowledgment

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