CONE CUTTER

Martin L. Syverson, Forester
Division of State & Private Forestry, U. S. Forest Service
Portland, Ore.

Good coniferous seed depends on the cone collector making cut tests on several cones from each tree before picking begins. The cone cutter should be lightweight, pocket-sized, and safe and simple to operate. The homemade cone cutter (see illustration on following page) is patterned after one first made by Homer Ward, Nurseryman, State of Washington Department of Natural Resources. It is made from a piece of metal conduit, ik saw blade, hardwood and rivets for handle, and a bolt to hinge the blade. Best results are obtained when the blade is kept sharp and the cone is cut lengthwise through the center with its tip facing away from the handle. A dull blade will compress the cone and make a ragged cut. This results in an inaccurate seed count. Cone collectors and buyers make cut tests to:

(1) Determine seed maturity.

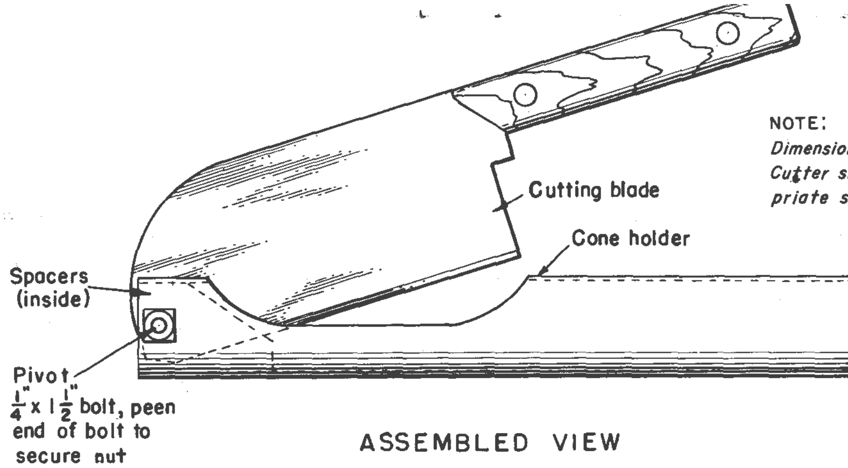
(2) Determine the seed count of a cone.

(3) Observe cone quality (pitch, worms, etc.).

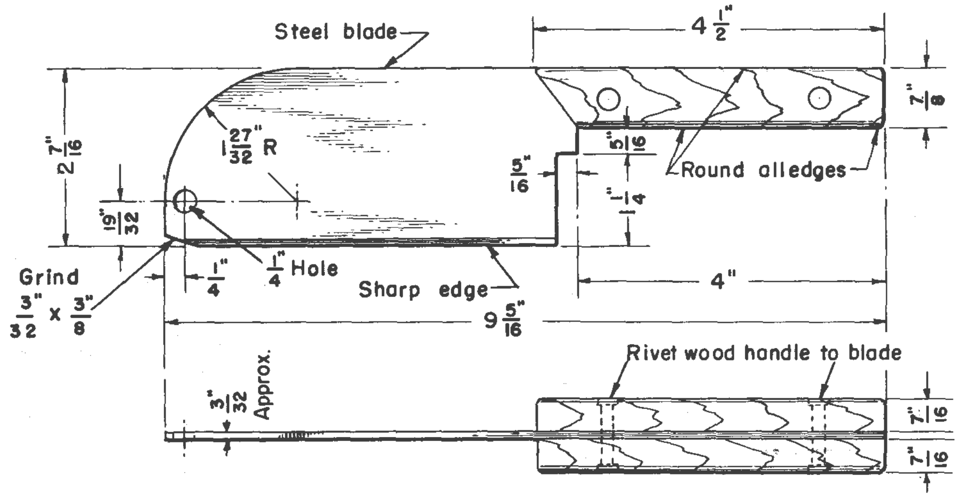
Tests for maturity start about the first of August. To be sufficiently mature, seed must be ripened beyond the "milk" stage and contain a solid white kernel. The seed count is determined by the number of sound seed kernels exposed by the cut on either half section of the cone. Seed count requirements vary with the species. Cone buyers usually require not less than six seed counts for Douglas-fir.

In the Pacific Northwest, cone picking usually starts in the middle of August for lower elevations and continues to early November for high elevations.

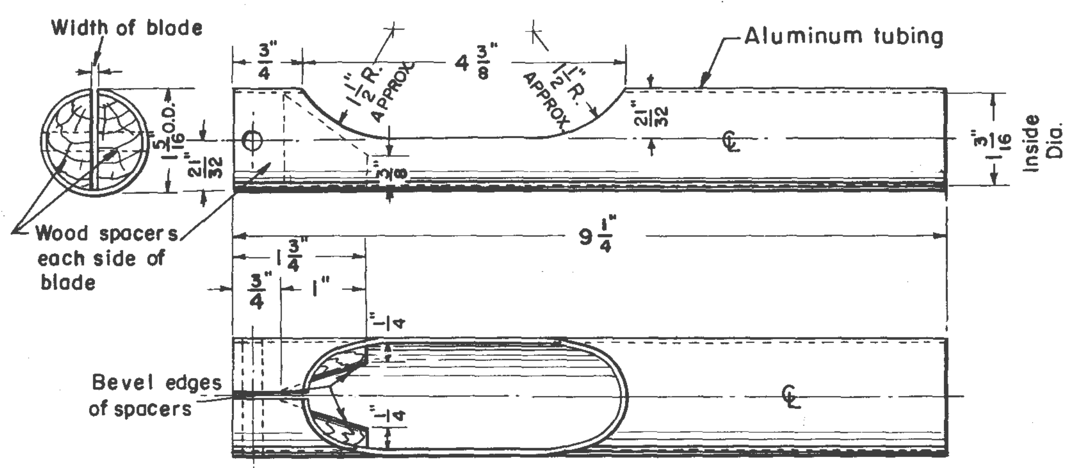
NOTE:
Dimensions shown are proportionate. Cutter should be built to an appropriate size for cone.



ASSEMBLED VIEW



DETAIL OF BLADE



DETAIL OF CONE HOLDER

DEWINGING DAMAGE TO SLASH PINE SEED

Thomas F. Swofford, Forester
Region 8 Tree Seed Testing Laboratory, U. S. Forest Service
Macon, Georgia

The seed coat of slash pine (Pinus elliottii Engelm.) is much softer than the coats of some of the other southern pines. It is characterized by a very thin outer coating, varying in color from tan to black, which is easily removed by rubbing. Scarification or removal of this coating from the outer seed coat is common during the dewinging process. Scarified areas on the seed are usually light brown.

The Region Eight Tree Seed Testing Laboratory makes germination tests for a majority of the tree nurseries in the southeastern United States. Slash pine seed received for testing is collected from all parts of the range of the species and is dewinged by various types of dewingers. Seed samples generally have from 25 to 50 percent of the seed scarified in varying degrees.

To study scarification damage, seed from nine lots were segregated on the basis of scarified and nonscarified seed. All seeds showing visible signs of scarification were classified as scarified. Seeds in this classification had surface injury ranging from a minute amount to markings on almost 100 percent of the surface. In the nine lots, scarification injury was found on 35 to 50 percent of all seeds. Germination tests on each lot are recorded as follows:

Lot	Full Seed Germination	
	Scarified	Nonscarified
	Percent	*Percent*
1	51	73
2	67	77
3	83	86
4	85	86
5	83	83
6	70	71
7	82	90
8	91	92
9	90	91

Germination loss from scarification, did not occur in all lots. Most of the low quality seed lots showed the greatest loss in germination. Scarification injury to seed of high vigor may be less damaging than injury to seed of low vigor.

Decreasing brush pressure in the dewinger is the solution to most scarification problems. This may result in increasing the number of partially dewinged seed. However, most planting machines can effectively sow the larger partially dewinged seed. If uniform sowing of a mixture of wholly and partially dewinged seed proves too difficult, sizing of seed may be necessary. For dewingers with adjustable brushes, regulation of the seed opening is simple. However, for those dewingers that are not adjustable, use of shorter brushes or redesign may be necessary.

STRATIFYING REPELLENT-TREATED PINE SEED

T. A. Harrington, Research Forester
Southern Forest Experiment Station, U. S. Forest Service
Sewanee, Tenn.

Germinative capacity of loblolly, shortleaf, and Virginia pine may be seriously reduced if the seed is repellent-coated and then stratified when fresh. In contrast, cold storage for a few months may largely forestall damage from later repellent treatment and stratification.

These are indications from studies at Sewanee, Tenn., where fresh clean seed of the three species was compared by laboratory germination after being processed in various ways. The treatments, and their effects on germination, were as follows:

Seed treatment	Germination		
	Loblolly pine	Virginia pine	Shortleaf pine
	Percent	*Percent*	*Percent*
Fresh, not stored; stratified 33 days:			
Repellent applied before stratification	68	61	85
No repellent, but stratified	97	97	96
Cold-stored for 2 months; stratified 23 days:			
Repellent applied before stratification	85	98	92
No repellent, but stratified	91	94	91

The repellent coating was a mixture of 6 pounds of Arasan-75 and 0.8 pound Endrin-50 per 100 pounds of seed. Latex 512-R was the sticker; a little aluminum powder was added to make the seed easy to handle. Stratification was in moist sand at 38-40 F. Storage was in a household refrigerator, also at 38-40 degrees.

MORE ON STRATIFICATION OF PINE SEED IN POLYETHYLENE BAGS

Barry F. Malac
Woodlands Research Department, Union Bag-Camp Paper Corp. Savannah, Ga.

Recently, studies of seed stratification using polyethylene bags showed distinct possibilities of this simplified method of breaking dormancy of pine seed. Hosner et al.,[1] stated that "... storing small samples of moistened (loblolly) seed in polyethylene bags shows promise as a substitute for stratification in sand as a pregermination treatment to break dormancy." Similar results are reported by T. V. Lehto[2] who found loblolly pine 14 seed stratification in polyethylene bags more economical, more flexible, and more convenient. In correspondence and personal discussions with the writer, T. F. Swofford, of the Region 8 Seed Testing Laboratory, notes that polyethylene bag stratification of loblolly pine compares favorably with treatments in sand and peatmoss; total germination resulting from all three treatments was about the same, and the speed of germination was identical for all three for 30- and 60-day stratification periods.

In August 1959, we initiated an exploratory study to find out whether this method of stratification might be feasible using larger quantities of seed. Specifically, our purpose was to determine if the positive results reported by others on small seed samples could be duplicated with larger seed lots of both loblolly and slash pine. The results, as reported here, may be of interest to nurserymen, direct seeders, and research workers planning more intensive tests of polyethylene bag stratification.

Experimental Procedure

The test as set up used only one stratification treatment- -polyethylene bags--plus an untreated control. We did not include any of the standard stratification treatments; the polyethylene bag technique had already been demonstrated as effective for small lots of seed, and the point being tested in this study was its effectiveness with larger seed lots.

In establishing the study, 100-pound lots of slash and loblolly seed were subdivided for treatment according to the following scheme:

Treatment and lot size	No. of replications
Polyethylene bag stratification:	
25 pounds	1
10 pounds	3
5 pounds	3
100 seed	4
Untreated control, 30 pounds	1

After each sample lot was weighed, the seed was placed in burlap bags and submerged in tapwater until thoroughly wet. Then each treated sample was poured out into a polyethylene bag, and sealed and labeled. All samples, both stratified and unstratified, were placed in cold storage and remained there for 60 days at temperatures of 36-38° F. During the stratification period the seedlots were inspected periodically and kept moist by adding water whenever needed.

At the end of 60 days, representative samples of seed were drawn from all treatment lots for standard germination tests to reveal differences, if any, between treatments and size of seed lot in stratification.

1 Hosner. F. John, et al, Storing loblolly pine seed in polyethylene bags as substitute for stratification. Jour. Forestry 57:495-496. 1959.

2 Lehto, T. V. Stratifying pine seeds in plastic bags. American Nurseryman, April 1960.

Results

The results obtained from these germination tests indicate that polyethylene bag stratification is quite feasible for operable seed lots up to 5 or 10 pounds, but is somewhat risky with lots as large as 25 pounds.

For loblolly pine, as expected, stratification. resulted in much higher germination rates than no treatment, as indicated:

Treatment and lot size	Total normal germination percent at 30 days[1]	Days required to reach 90 percent total germination
Polyethylene bag stratification:		
25 pounds	80.0	20
10 pounds	84.8	20
5 pounds	89.5	15
100 seed	89.6	17
Untreated control, 30 pounds	44.7	26

[1] Based on total number of seed or "apparent germination percentage."

The table shows a drop of almost 10 percentage points in total normal germination as between the very small sample of 100 seed and the large sample of 25 pounds of seed. There was practically no difference between germination rates of the 100-seed and 5-pound samples. It is also interesting to note that the 100-seed and the 5-pound lots reached 90 percent of their total germination in substantially fewer days than the larger lots being tested.

Stratification of the slash pine seed resulted in general depression of germination rates. (Slash seed is known to respond erratically to stratification treatments of any kind.) The rates of germination obtained with this species were as follows:

Treatment and lot size	Total normal germination percent at 30 days[1]	Days required to reach 90 percent total germination
Polyethylene bag stratification:		
25 pounds	60.6	11
10 pounds	63.9	9
5 pounds	63.7	9
100 seed	86.2	8
Untreated control, 30 pounds	85.2	13

[1] Based on total number of seed or "apparent germination percentage."

Germination of the very small (100-seed) lot of stratified slash was about the same as that for the untreated control seed. There is a sharp drop in germination rate, however, as seed are stratified in larger lots.

Conclusions

It had been demonstrated previously that stratification of small, 100-seed sample lot; in polyethylene bags gives equally as good results as conventional methods of stratification in peat moss or sand. Tests were needed, however, to see if larger, more practical lot: of seed could be stratified using the same technique with comparable results. This was the primary purpose of the present study; we needed to determine if polyethylene bag stratification of larger seed lots resulted in the same germination as polyethylene bag stratification of 100-seed lots. On the basis of our results, we conclude that seed lots as large a.

5 pounds in size may be stratified in polyethylene bags with no ill effects or loss of germination.

Our tests using 10-pound seed lots gave fairly good results, but the loss of about five percentage points in total germination might be unacceptable. The 25-pound seed lot seems to be too large to handle and, furthermore, the germination loss of almost 10 percent and the 5-day increase in germination period make it appear undesirable. However, this is the weakest point in our test, since we had only one replication of this treatment. It might be that with some modification of the technique even such large lots could be stratified using polyethylene bags with no losses in germination.

The 5-pound seed lot seems to be the best size, at least as far as these tests are concerned. Lots of this size are easy to handle, and total germination is as great as that from smaller seed lots. If stratification of loblolly or slash seed is called for, and if the nurseryman wishes to employ a simpler, cleaner technique than use of sand or peat moss, then we would recommend that he use polyethylene bags and seed lots of about 5 pounds in size.

LIQUID FERTILIZER TREATMENTS OF NURSERY SOILS-THEIR ADVANTAGES AND SHORTCOMINGS [1]

S. A. Wilde, Professor of Soils
Soils Dept., College of Agriculture, Univ. of Wisconsin
Madison, Wis.

The use of liquid fertilizers in forest nurseries was introduced in the summer of 1932 when several blocks in two Wisconsin nurseries were treated with a solution of ammonium sulfate, diammonium phosphate, and potassium nitrate. Because of the spectacular response of seedlings to liquid treatments, the method attracted the immediate attention of nursery specialists. Within a few years, the application of fertilizer solutions through sprinkling cans, pressure sprayers, and overhead systems became a common practice in many nurseries (Wilde, 1935). At present, the practice is widely used, with or without justification, in this country and abroad.

No other method of nursery soil management has rendered such helpful services or brought such harmful consequences as has the use of liquid fertilizers. A review of the beneficial and the harmful aspects of this practice follows.

Applications of fertilizers ahead of seeding require plowing and discing, or rototilling. Liquid treatments are much less laborious. As recently shown by Krause (1960), application of fertilizer solutions on densely-stocked nursery beds nearly eliminates the losses of nutrients by leaching and fixation because the entire content of applied salts is intercepted by foliage and root systems. The use of fertilizer solutions permits the correction of nutrient deficiencies in soils which have not received enough fertilizers prior to seeding, or in which the supply of available nutrients has been reduced by heavy rains, unexpectedly high germination of seed, activity of micro-organisms, or inter-action with biocidic compounds.

An important advantage of fertilizer solutions, not fully utilized until recent times, is their use as foliar sprays. The ability of plants to absorb nutrients by their foliage permits the use of very minute amounts of fertilizer salts. Thus, in the treatment of vineyard soils with zinc sulfate, a foliar spray of a mere 6 grams per acre produces the same beneficial result as does an application of 30 pounds per acre to the soil (Dobroliubsky, 1956).

Aside from financial savings, this reduction in the amount of applied chemicals is of particular importance in the production of nursery stock. It permits correction of the constantly increasing deficiencies of minor elements (boron, manganese, copper, zinc, and molybdenum). The salts of these elements are applied in minute quantities because they are toxic to tree seedlings.

To summarize, using fertilizer solutions is a valuable auxiliary method of maintaining nursery soil fertility. Yet such solutions cannot entirely replace the application of fertilizers to the soil. One reason is that it is impossible to maintain the fertility of a permanent nursery soil without using peat, catch crops, lime, and the slowly soluble fertilizers of major elements, particularly the phosphates. More important is the fact that unless nursery soil has a supply of buffered nutrients which is well distributed in the root-bearing zone, the stock will fail to develop an adequate root system. In a large measure, the harmful effect of fertilizer solutions is due to their nitrogen content, which is responsible for an increased concentration of indol-acetic acid in the plant sap. At a certain concentration of this acid, the growth of the root system is arrested, whereas the growth of the crowns proceeds at an increased rate (Bosemark, 1954).

Therefore, maintenance of soil fertility by means of fertilizer solutions alone, or even indiscriminate application of liquid fertilizers, will in time lead to the production of

1 Contribution from Soils Department, University of Wisconsin. with financial support and cooperation from the Wisconsin Conservation Department, Publication approved by the Director of the Wisconsin Agricultural Experiment Station.

inferior planting stock with unsatisfactory top-root ratio, succulent crowns, and unbalanced physiological makeup (Wilde, 1958).

During the past few years, fertilizer solutions have been replaced in some nurseries by the top dressings of solid fertilizers, spread between rows of seedlings by a seeding machine. This practice, the outcome of a general tendency to simplify the operation and reduce the cost of labor, has several serious disadvantages. Because of the fixed formulas of commercial fertilizers, a single top dressing can seldom provide the desirable ratio of nutrients. The surface application of fertilizers occasionally gives rise to a very high concentration of the infiltrating solution which causes severe burning of the surface roots of trees, especially in 1-year-old seedlings. In addition, much of the applied fertilizers may become unavailable to plants upon contact with the soil because of the chemical or biological fixation. All in all, this modification of fertilizer treatments has highly questionable merits; in unskilled hands, it is likely to deteriorate the quality of planting stock and bring considerable financial losses.

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ECONOMIC CONSIDERATIONS OF GROWING AND GRADING SOUTHERN PINE NURSERY STOCK

T. H. Silker, Associate Silviculturist Texas Forest Service Kirbyville, Tex.

This report has been prepared to: (1) draw attention to management trends in some southern pine nurseries in the last decade, (2) point up apparent nursery and reforestation problems, and (3) report results of 10-year objective studies undertaken by the Texas Forest Service that may contribute to the direction, success, and economic returns of future reforestation efforts.

In the late 1940's, it was apparent that managers of some southern pine nurseries considered production quantity as the prime management goal. Wakeley's book[1] served to temper this outlook and directed attention to production by morphological grade.

About 1952, there was general acknowledgment that soil conditioning should be stepped up on many of the older nurseries. With the increased use of sawdust as a soil conditioner came moderate to heavy applications of commercial fertilizers. Production goals of 1 to 1-L million shippable seedlings per acre soon became common and existing nurseries struggled vainly to meet seedling orders. With the advent of the Soil Bank program, the race was, on to set up new nurseries and get them into production in 1957 in anticipation of a large seedling demand.

Seedling production at some locations again suggested "production fever." Morphological grades were still used to grade and ship seedlings; however, soil conditioning and fertilizer applications were about the same as those carried out on pre-Soil Bank nurseries, even though the new locations were on soils that had been in pasture or weed fallow for years. Critical examination of recent research work suggests that such practices may make it difficult to hold seedlings within morphological standards and may further complicate effort to produce seedlings of desired physiological grade.

The following is a summary presentation of data and supplementary comment covering grade-recovery and out-planting tests of slash and loblolly pine during the years 1948-52.

Procedure

Six seedling-grade classes of 1-0 slash and loblolly pine were established to test survival and growth response. Grade separations were made by stem-diameter[2] groups within the following top-height classes:

Class	Height	Stem diameter
	Inches	*Inch*
Small	3.0 - 5.9	1/20 and 2/20
Medium	6.0 - 8.9	2/20 and 3/20
Large	9.0 - 11.9	3/20 and 4/20

The "small" 1/20-inch diameter seedlings were principally "blue-tops," with primary needles predominating.

1 Wakeley. Philip C. Planting the southern pines. U.S. Dept. Agr„ Agr. Monog. 18, 233 pp. 1954.

2 Measured at 1 inch above root collar.

Four, 1-square foot random samples were taken from randomly selected nursery beds to determine grade-recovery ratios for each species and each bed-management practice; e.g.; broadcast, 4-row, 6-row, or 8-row seeded beds. These recovery studies were made annually over a period of 3 years at the Indian Mound Nursery at Alto, Texas.

Two lots of 50 seedlings, for each grade, were outplanted in 1949 in Caddo soil. Similar lots were planted on two Caddo soil locations and one Bowie soil each year, for the following 3 years. All plantings were located on upper flatwood soils within an area 20 miles in diameter.

Table 1 shows third year survival pattern of the 1-0 stock, by various seedling grades, for the 1950, 1951, and 1952 planting seasons.

Table 2 and figure 1 illustrate height and diameter development of grades. The important responses noted are as follows:

a. There is approximately a direct line response between survival and height development and increases in stem diameter and top length.

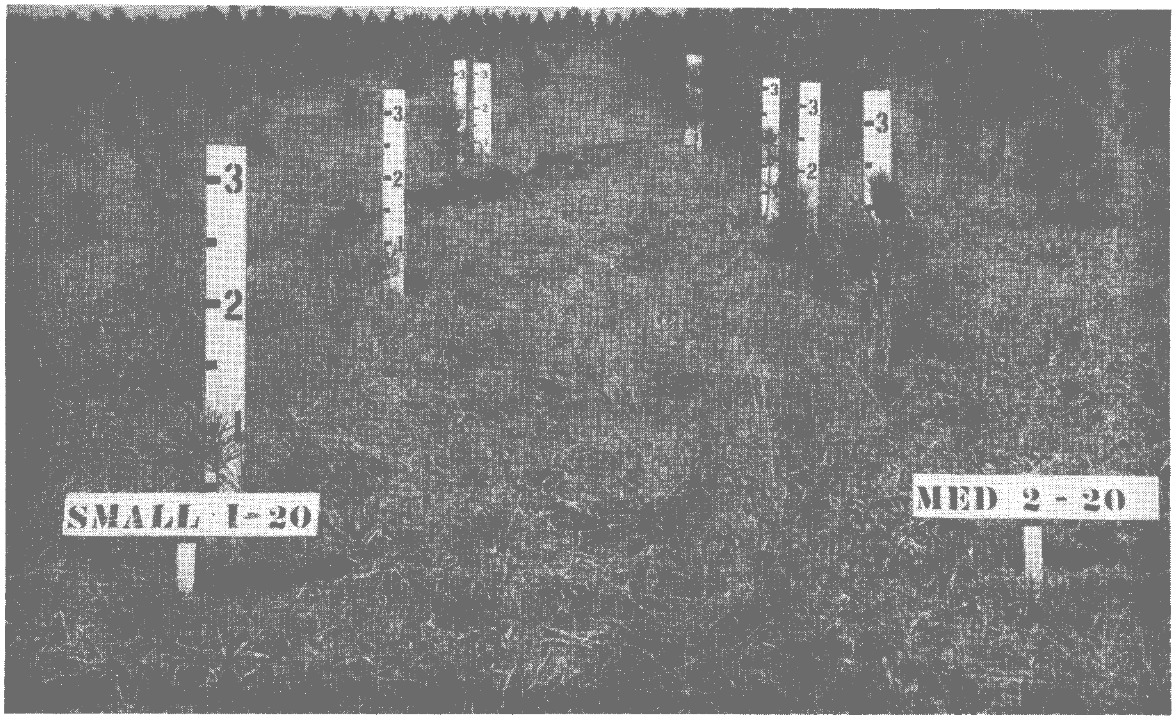
b. Loblolly consistently showed better survival than comparable grades of slash pine exposed to protracted periods of summer drought. Apparently, loblolly has an inherent physiological advantage for given size classes over slash pine, or it may reflect earlier maturity at a given age under common conditions. This is evidenced by terminal bud formation, woody stem, and fascicled needle development in a high percentage of even the "small" seedling group.

c. Premium seedlings are suggested as those with 50 percent fascicled needles, exceeding minimum 3/ 20-inch stem diameter, and 6- to 12-inch top length for loblolly, and 6- to 9-inch top length for slash pine. Larger slash pine seedlings attained greater growth in good planting years but did not have as consistent good survival in dry years.

TABLE 1.--Survival percent of slash and loblolly 1-0 stock, by seedling grade, after three growing seasons on Bowie and Caddo Soils of lower Coastal Plain

Growing season planted and species	Small top 3.0-5.9 inches and stem diameter of--		Medium top 6.0-8.9 inches and stem diameter of--		Large top 9.0-11.9 inches and stem diameter of--		Total rainfall[1]
	1/20 in.	2/20 in.	2/20 in.	3/20 in.	3/20 in.	4/20 in.	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Inches*
1950:							45
Slash............	25	58	72	89	59	79	
Loblolly.........	32	54	59	75	78	84	
1951:							44
Slash............	4	14	21	26	18	17	
Loblolly.........	17	32	54	58	70	67	
1952:							54
Slash............	11	22	21	25	25	28	
Loblolly.........	23	55	50	52	55	54	
3-year average:							
Slash............	13	31	38	47	34	41	
Loblolly.........	24	47	54	62	68	68	

[1] Deficient during growing season each year.



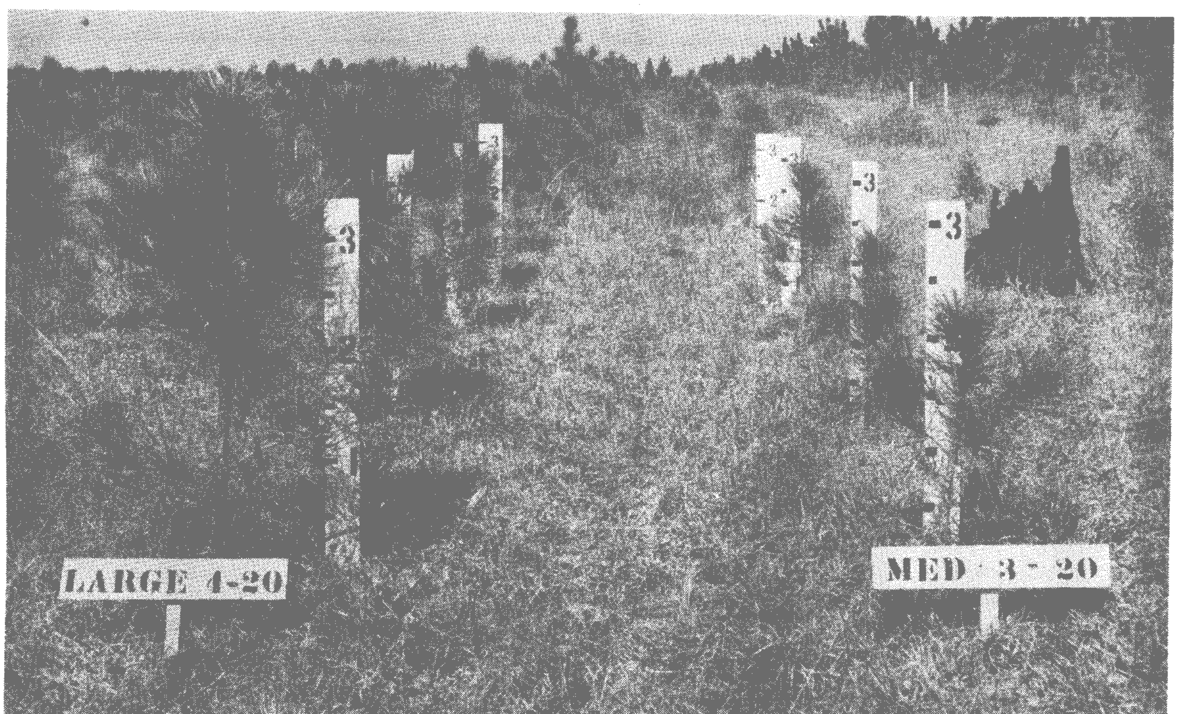


Figure 1. Development of graded slash pine seedlings on Caddo soil at end of third growing season. Survival pattern is suggested by absence of stakes at 6 foot intervals.

TABLE 2.--Average height and diameter development per annum of slash and loblolly 1-0 seedlings, by grade, on Caddo soil[1]

Height[2] Growth per Annum

Species and age of planting	Small top 3.0-5.9 inches and stem diameter of--		Medium top 6.0-8.9 inches and stem diameter of--		Large top 9.0-11.9 inches and stem diameter of--	
	1/20 in.	2/20 in.	2/20 in.	3/20 in.	3/20 in.	4/20 in.
	Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
Slash:						
8..................	1.79	2.13	1.98	2.03	2.03	2.13
8..................	1.93	2.09	1.89	2.14	2.12	2.29
9..................	[3] 1.68	[4] 2.26	1.86	2.00	2.09	2.17
9..................	[5] 1.68	2.20	2.26	2.26	2.49	2.40
11..................	1.76	1.73	2.09	2.23	2.30	2.43
Mean..............	1.77	2.08	2.02	2.13	2.21	2.28
Loblolly:						
8[6].................	.75	.78	.81	.98	.96	.98
8..................	1.20	1.28	1.45	1.51	1.56	1.63
9..................	--	1.13	--	1.43	--	1.40
11[6].................	.64	.85	.67	.89	.98	.80
Mean..............	.86	1.01	.98	1.20	1.17	1.20

Diameter Growth per Annum

Species and age of planting	Small 1/20 in.	Small 2/20 in.	Medium 2/20 in.	Medium 3/20 in.	Large 3/20 in.	Large 4/20 in.
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
Slash:						
8..................	0.35	0.50	0.48	0.51	0.49	0.53
9..................	.40	.49	.47	.50	.51	.52
10..................	.31	.31	.38	.37	.40	.45
Mean..............	.35	.43	.44	.46	.47	.50

[1] Bowie soil locations damaged by wildfire.
2 Average of two replications, each location.
[3] 2 trees.
[4] 6 trees.
[5] 1 tree.
[6] Heavily retarded by tip-moth damage.

d. "Spindly" seedlings, such as those having 3/20-inch diameter and 9-inch top length with few fascicled needles, were the most susceptible to cold desiccating winds occurring immediately after planting or to protracted summer drought.

e. Height and diameter development indicate concerted effort should be made to grow and grade seedlings for maximum numbers of premium grade. Such trees, when planted in the field, showed promise of the greatest economic return.

f. Slash pine outgrew loblolly in the juvenile period. Loblolly was seriously retarded by tip-moth damage at one location but was only lightly retarded at other locations. Growth of both species was consistently greater on well-drained Bowie soils than on moderately to poorly drained Caddo soils.

g. There was little difference in production of acceptable seedlings by method of seeding, whether seeded broadcast or by 4-, 6-, or 8-row beds.

Data from this study indicate stress should be placed on growing medium-sized seedlings that show a strong reddish-purple color after a few hard frosts, and low incidence of terminal "surge" or flush growth. Such seedlings usually show good physiological maturity by having 50 percent or more live crown in fascicled needles and a high frequency of terminal bud.

Table 3 lists the grading standards used for shipment of 1-0 stock in Texas Forest Service nurseries during the current planting season. Although morphological standards are used to define grades, only those standards are used that will tend to eliminate most of the physiologically immature seedlings. These standards are more specific than the standards Wakeley offers, and thus concentrate attention toward judging physiological maturity minimums. Note that the minimums for fascicled needles are in strong contrast to "part at least in 3's and 2's" used in past grading. Spindly, succulent-stemmed seedlings are thus discarded as culls even though they meet previous standards as No. 2 stock.

In essence, the normal population curve is visualized when grading. The selection process lops off individuals at both ends and retains individuals from the more stable, medium-sized population at center. Even though survival and development are favorable for "large" loblolly, it is desirable to exercise reserve in the production and shipment of such seedlings until tendency toward extreme limbiness, potential form, and susceptibility to Cronartium are defined.

TABLE 3.--Grading standards for shipment of 1-0 slash and loblolly pine from Texas Forest Service nurseries

Grades and species	Stem diameter[1]	Top length	Top[2] and root condition[3]
	Inches	*Inches*	
Minimum acceptable:			
Slash	3/32	5-8	25 percent or more of live crown in fascicled needles; buds may be absent.
Loblolly	3/32	3-8	25 percent or more of live crown in fascicled needles, buds usually present.
Premium:			
Slash	4/32-10/32	6-9	50 percent or more of live crown in fascicled needles; buds usually present.
Loblolly	4/32-10/32	6-12	Do.
Maximum acceptable:			
Slash	4/32-10/32	9-12	50 percent or more of live crown in fascicled needles; buds present.
Loblolly and Slash	5/32-12/32	13-15	Do.

[1] At ground line--minimum to usual maximum.
[2] Fascicled needles reddish purple in most seedlings. Stem mostly woody.
[3] All roots a minimum of 5 inches in length, with well-developed laterals.

Visual-aid guide panels have been developed by the Texas Forest Service to depict minimum seedling character for each grade. These are used for personnel training and reference at the grading table. When consumer demand approximates nursery production, grading may be extended to include minimum and maximum acceptable grades. If demand is less than production, confinement to premium grade is suggested.

The impact of the preceding is more evident if we relate it to economics. Eleven year growth records of "small" splash pine reveal an average height of 19.2 feet on Caddo soil. Juvenile height for 3/20-inch diameter stock, "medium" and larger, averages 25.5 feet. Average d.b.h. at 10 years for these groups is 3.1 and 4.1 inches, respectively. If the 1-inch differential is carried forward to rotation end at 50+ years on an average site index 80, there may be a stocking differential of about 4.1 m. board feet per acre. This, at an average stumpage evaluation of $40 per m., would provide a $164 per acre advantage from using premium stock.

Although Wakeley and Hatcher[3] touch only briefly on economics, it is believed that nursery managers can make the most bold break and cross a "new threshold" of emphasis in working with potential planters. In addition to the tangible values that accrue from research and technical application, there are highly important intangible values that we consider, such as public relations. It is hoped the above may help attain balance when considering the ebb and flow of consumer demand for future reforestation stock.

3 Hatcher, John. Prescription planting guide for technical foresters (10 pp. mimeo), 1958.

SEEDBED DENSITY INFLUENCES PRODUCTION AND SURVIVAL OF LOBLOLLY AND SLASH PINE NURSERY STOCK

Eugene Shoulders
Southern Forest Experiment Station
Forest Service, U. S. Department of Agriculture
Alexandria, La.

Recent studies in Louisiana have shown that a nursery bed density of about 40 slash or loblolly pine seedlings per square foot is preferable to lower densities in terms of both plantable size and effective seedlings produced. (Effective seedlings are plantable seedlings that survive 1 year in the field.) If the criterion is larger seedlings or more grade-1 stock, lower bed densities may be desirable.

Densities of approximately 10, 20, 30, and 40 seedlings per square foot of nursery bed were compared in these studies. Seedlings for two studies were grown in a small experimental nursery and those for the third in two of the Louisiana Forestry Commission's nurseries. Weeding, watering, spraying, and fertilizing were according to usual nursery practices. Soils were not fumigated, but no evidence of nematodes or root rot was observed.

Desired stocking levels were obtained by oversowing the plots and thinning them after germination was complete. As a few extra seedlings were retained in thinning to allow for expected summer mortality, final densities did not agree precisely with those prescribed (table 1).

Densities were replicated in the nursery and in outplantings. Nursery plots varied in size from 3-1/2 to 10 linear feet of bed. Field plots were rows of 25 trees. In the course of the studies more than 16,000 seedlings were graded and more than 5,000 were planted.

Size of Planting Stock

The best seedlings, in terms of morphological quality, were produced at a density of 10. They had stouter stems but no more height than those from denser beds.'

Plantable slash pines from low- density beds averaged 7/ 32 to 10/32 inch in rootcollar diameter, while those from high-density beds averaged 4/32 to 6/32. The pattern was about the same for loblolly, though diameters were slightly smaller (table 1).

The proportion of total production in various morphological grades is a good measure of the effect of bed density on physical suitability of seedlings for planting. Seedlings of the highest morphological quality (grade 1) are 3/16 inch or larger in rootcollar diameter and 5 to 12 inches (loblolly) and 6 to 14 inches (slash) in height. Nearly all needles of grade-1 stock are fascicled, and bark usually covers the entire stem. Seedlings of the other plantable grade (grade 2) are at least 1/8 inch in rootcollar diameter and at least 4 inches (loblolly) or 5 inches (slash) tall. They must also have some secondary needles and bark on the lower stem.

In these studies, more than 90 percent of the seedlings raised at a density of 10 were plantable, and over 70 percent were grade 1. In contrast, every third or fourth seedling from the plots of highest density was too small to plant, and less than 50 percent of the total production was grade 1.

Yield of Plantable Seedlings

The number of plantable seedlings of both species increased with each increase in density. The nominal density of 10 produced an average of 11.4 plantable slash and 12.4 plantable loblolly seedlings per square foot (table 1). Increasing density to 20 per square foot yielded an additional 8.8 slash and 7.0 loblolly of plantable size. Further increases from 20 to 30 and from 30 to 40 seedlings per square foot produced 6.5 and 3.5 additional

TABLE 1.--How nursery bed density affected size, yield, and survival of loblolly and slash nursery stock

Slash Pine

Study and nursery	Actual bed densities per square foot	Production per square foot of--		Proportion plantable	Size of plantable stock		First-year survival
		Plantable seedlings	Effective seedlings		Rootcollar diameter	Height	
	Number	*Number*	*Number*	*Percent*	*Inches*	*Inches*	*Percent*
1.........	11.3	11.0	10.1	97	9/32	10	92
	21.9	20.4	16.9	93	7/32	9	83
	32.1	27.2	20.6	85	6/32	10	76
	41.9	29.2	22.2	70	6/32	10	76
2.........	13.8	13.3	5.7	97	7/32	10	43
	23.2	20.6	7.8	89	6/32	11	38
	33.8	23.7	12.1	70	5/32	10	51
	44.9	29.7	9.8	66	4/32	10	33
3-A.......	10.8	10.0	9.8	94	10/32	7	98
	21.8	19.8	18.2	91	8/32	8	92
	31.6	27.8	25.2	88	6/32	7	90
	42.1	32.5	30.3	77	6/32	8	93
3-B.......	12.0	11.3	11.0	95	8/32	7	97
	22.1	20.0	19.0	90	7/32	7	95
	32.7	28.0	25.2	86	6/32	7	90
	38.1	29.3	28.2	77	6/32	8	96
			Loblolly Pine				
1.........	11.3	(1)	(1)	(1)	7/32	10	91
	20.0	(1)	(1)	(1)	6/32	10	86
	29.8	(1)	(1)	(1)	6/32	9	82
	38.9	(1)	(1)	(1)	5/32	8	82
2.........	14.4	13.6	12.1	94	7/32	10	89
	23.8	18.7	15.0	79	6/32	10	80
	37.9	24.0	18.5	63	5/32	8	77
	48.9	25.8	19.9	53	5/32	8	77
3-A.......	13.4	12.2	12.2	91	8/32	7	100
	21.6	19.7	19.7	91	6/32	7	100
	35.1	26.3	25.6	75	6/32	7	97
	43.8	29.8	28.6	68	5/32	7	96
3-B.......	11.8	11.5	11.5	97	8/32	11	100
	21.2	19.9	19.4	93	7/32	10	99
	30.9	26.8	26.5	87	6/32	11	99
	39.3	31.1	30.4	79	6/32	11	98

[1] No data.

plantable slash, respectively, and 6.3 and 3.2 additional plantable loblolly. A projection of this trend indicates that increases beyond 40 per square foot would bring little net gain in plantable seedlings.

Survival

Studies 1 and 2 were outplanted in moderately dry years. In the first planting, plantable seedlings from beds of lowest density survived best--92 percent of the slash and 91 percent of the loblolly were alive at the end of the first year. Field survival decreased as density was increased to 20 and 30 seedlings per square foot. Here densities of 30 and 40 gave equally good survival for both species. Similar trends were found in outplanting number 2 except that, for reasons unknown, survival of all slash pine was low, and seedlings grown at a density of 30 survived better than those at other densities.

Study 3 outplantings received adequate summer rain, and first-year survival was 90 percent or higher for both species at all densities.

The effect of weather on survival must be considered in interpreting these results. The data show that trees grown at low density withstood drought better than those grown at high density. They also indicate that, in more favorable years, high survival can be attained at any density in the range tested.

Effective Seedlings

Number of effective seedlings is a more rigorous measure of nursery bed density than either the yield of plantables or field survival. As has been mentioned, effective seedlings are plantables that survive their first year in the field. To illustrate, if one square foot of bed yields 30 plantable trees and 80 percent of them survive, the number of effectives is 24. Because summer droughts are frequent in the southern pine region, the following estimates are based on data from the research plantings in dry years-slash data are from study 1, and loblolly from study 2.

The number of effective seedlings produced at the 40 density was estimated to be 622,000 slash and 557,000 loblolly pines per acre of nursery. This was 45,000 more slash pines than were obtained from a' density of 30; 148,000 more than from a density of 20; and 339,000 more than from a density of 10. Comparable values for loblolly pine were 39,000, 137,000, and 218,000 effective seedlings per acre. (These calculations assume that an acre of nursery contains 28,000 square feet of bed space.)

As with plantable seedlings, the gains diminished sharply with each increase in density. Between densities of 30 and 40, the gain averaged only 45,000 per acre for slash and 39,000 for loblolly. Consequently, densities much above 40 per square foot appear impractical.

Assuming that seedlings should be grown for outplanting in adverse years, was the density of 40 more efficient than 30? The only additional expenses associated with the extra effective seedlings from the denser beds were those for seed and for the labor of lifting and grading.

With average numbers of seeds per pound and a tree percent of 70, 28 pounds of slash seed and 22 of loblolly were required to increase bed density from 30 to 40. If slash seed costs $3 per pound and loblolly $4, the extra seed amounts to $84 and $88 per acre, respectively. Lifting and grading cost about $0.50 per thousand for bed-run seedlings, and it was necessary to handle an additional 274,000 slash seedlings per acre and 308,000 loblolly to realize the increases in effectives. Thus, the extra effective seedlings cost about $5.50 per thousand ($6.20 for loblolly and $4.90 for slash). As each thousand effectives represented about 1,300 plantable seedlings, the investment per thousand plantables was about $4.25. Densities of 40 per square foot therefore appear well justified, for few if any southern nurseries are producing plantable seedlings for less than $4.25 per thousand.

EFFECT OF SOIL FUMIGATION IN THE NURSERY ON GROWTH OF LOBLOLLY PINE SEEDLINGS AND CONTROL OF WEEDS

Charles S. Hodges, Pathologist
Southeastern Forest Experiment Station
U. S. Forest Service,
Raleigh, N. C.

Methyl bromide and Vapam as general soil fumigants for the control of fungi, nematodes, and weeds have been widely tested in forest nurseries (Briscoe and Strickland, 1956; Clifford, 1951; Foster, 1956; Henry, 1951; Hill, 1955; Stoeckeler, 1951; Wycoff, 1952). The excellent and consistent results obtained with m ethyl bromide to control weeds and increase total plantable seedlings make it probable that this fumigant would be in wider use were it not for the large amount of hand labor involved. The limited area that can be fumigated daily is also a serious drawback, since the soil is not warm enough for fumigation until planting time has almost arrived, and bad weather may prevent treatment.

Water-sealed Vapam has also been widely tested in forest nursery soils, but it has not been uniformly effective in controlling weeds and soil-borne diseases. For this reason, it has not been used more widely in forest tree nurseries.

In 1959, a study was undertaken at the Little River Nursery near Goldsboro, N. C., to compare the effectiveness of various formulations and techniques of applying methyl bromide and Vapam in controlling weeds and increasing seedling growth. In addition, several combinations of Eptam, a herbicide, and Nemagon, a nematocide, were also tested. These materials were included since they would be much cheaper to use than the general-purpose fumigants for certain specific objectives. For the most part, the materials tested had been used before and are commercially available. The major purpose of the study was to compare known effective treatments for the problems existing at the Little River Nursery. The results of the study, however, may be applicable to other southern forest nurseries or may serve as guides for future tests in other areas.

Only one material, Brozone, had not been used previously on forest nurseries. In California, this material has been effectively used for the control of weeds, nematodes, and soil-borne fungi at rates as low as 150 pounds actual methyl bromide per acre (Sher et al., 1958; Thomason, 1959; Wilhelm et al., 1958; Wilhelm et al., 1959). This material contains, by volume, 50 percent methyl bromide and 50 percent of a petroleum carrier. Brozone is injected into the soil with chisel applicators and then the soil is covered with polyethylene covers.

Procedure

The tests were laid out in a randomized block design with three replications of each treatment. Each plot was 60 by 4 feet. Weed ratings were made 6 and 12 weeks after planting, on a rating system of 0 to 10, with 0 indicating complete control and 10 no control. All the plots were weeded by hand following the first rating, since the weeds in some plots were interfering with normal seedling growth. After the second rating, the plots were weeded by applications of mineral spirits or by hand.

At digging time, all the seedlings in a 4- by 4-foot area in the center of each plot were lifted and graded according to Wakeley's morphological grades (Wakeley, 1954). The average weight per seedlingwas taken by averaging the weights of every 25th plantable seedling selected during the grading operation.

The following treatments were included in the study:

1. Methyl bromide

A. as the standard treatment[1] of 1 pound per 150 square feet (300 pounds per acre) released under a 4-mil polyethylene cover.

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1 The chemicals used in this study were contributed by the following companies: Vapam and Eptam. Stauffer Chemical Co.; Brozone, Hendrix-Barnhill Co., Greenville. N. C.; vaporized methyl bromide. Dow Chemical Co. Mention of any chemical company or product does not imply endorsement by the U. S. Department of Agriculture.

B. vaporized and released at the rate of 300 pounds per acre under a 2-milpolyethylene cover put down with an automatic covering device made by Dow Chemical Company.

C. as Brozone at the rate of 175 pounds per acre actual methyl bromide, injected into the soil and covered with a 2-mil polyethylene cover or left uncovered.

2. Vapam

A. at 50 and 100 gallons per acre drenched into the soil with 1300 gallons water.

B. at 50 gallons per acre drenched into the soil and covered for 2. days with a 2-mil polyethylene cover.

3. Eptam

A. in liquid form at the rate of 6 pounds active ingredient (1 gallon) in 75 gallons water per acre applied to the soil surface and disked in.

B. as in A with an additional 6 pounds in 75 gallons water sprayed on seedlings 6 weeks later.

C. as in A plus 50 gallons per acre Vapam.

D. as in A plus 1 gallon per acre (active ingredient) Nemagon.

E. in the granular format the rate of 6 pounds per acre active ingredient applied on the surface and disked in.

4. Nemagon

A. in the granular form at the rate of 1 gallon per acre active ingredient applied to soil surface and disked in.

5. Check--no treatment.

All treatments were applied at least 2 weeks before planting. The area of the Little River Nursery, where the tests were conducted, is classified as a Wickham fine sandy loam soil.

Results

Considering all criteria measured in the study, the covered Vapam, covered Brozone, standard methyl bromide, and vaporized methyl bromide treatments were significantly superior to no treatment (table 1). The treatment with noncovered Brozone resulted in a significant increase in the number of plantable seedlings. However, seedlings were much smaller than those in the above treatments and weed control was inadequate.

The water-sealed Vapam treatments neither increased seedling size nor lowered weed rating. The fact that this material gave excellent results in all respects when sealed with a polyethylene cover is good evidence that the poor results obtained in the past with this material are due to failure to get an adequate seal with water.

Weed control with both the liquid and granular formulations of Eptam was excellent through 12 weeks but this material did not significantly increase seedling growth.

Nemagon only slightly increased seedling size, indicating that nematodes are not a major factor at this nursery. Weed ratings were significantly increased with this material at the 6-week rating period and were higher than the check at the 12-week rating.

TABLE 1.--Effect of various soil fumigants on growth of loblolly pine seedlings and weed control

Chemical	Rate per acre	Seedlings per square foot		Average seedling weight	Weed rating	
		No. 1	Plantable		6 wks.	12 wks.
		Number	*Number*	*Grams*		
Methyl Bromide (standard)..........	300 lbs.	1.7**	42.1**	10.2**	1.3**	1.7*
Methyl Bromide (vaporized)..........	300 lbs.	0.9**	31.3*	10.1**	2.7*	2.0*
Brozone (covered)......	175 lbs.	2.8**	32.6*	12.8**	1.3*	1.7*
Brozone (not covered)..	175 lbs.	0.1	30.3*	5.9	3.3	4.0
Brozone (not covered)..	350 lbs.	0.0	32.0*	6.5	3.0	3.7
Brozone (not covered)..	525 lbs.	0.2	31.3*	7.7*	3.0	3.3
Vapam (water sealed)...	50 gal.	0.0	25.1	6.9	5.0	4.3
Vapam (water sealed)...	100 gal.	0.0	16.3	5.7	5.3	6.0
Vapam (covered)........	50 gal.	1.5**	37.8**	9.9**	1.0**	1.0**
Granular Eptam.........	6 lbs.	0.1	32.1	7.3	1.3*	2.0*
Liquid Eptam...........	6 lbs.	0.0	28.5	7.1	1.7**	5.3
Liquid Eptam)....... + Liquid Eptam).......	6 lbs. 6 lbs.	0.0	26.2	6.2	2.7*	2.0*
Liquid Eptam)....... + Vapam).......	6 lbs. 50 gal.	0.0	20.5	6.9	1.0**	2.3
Liquid Eptam)....... + Nemagon).......	6 lbs. 1 gal.	0.0	21.7	5.5	2.3*	3.7
Nemagon................	1 gal.	0.1	24.3	7.3	9.0**	7.0
Check..................	--	0.0	17.0	6.2	5.3	5.0
LSD, 5 percent.......		0.5	11.8	1.5	2.6	3.1
LSD, 1 percent.......		0.7	15.9	2.1	3.5	4.1

*Denotes significance at the 5 percent level.
**Denotes significance at the 1 percent level.

Discussion

From the standpoint of a general soil fumigant, covered Brozone appears to be very promising. At present this material is available only by contract application by a Dow Chemical Company distributor. Based on contract prices for over 100 acres of nursery soil to be fumigated in North Carolina and South Carolina, the cost of fumigation with Brozone is about equal to or even less than the cost for the standard application of methyl bromide with 1-pound cans and 100 by 20-foot covers. On the basis of the present studies and on inspection of tobacco plant beds treated with Brozone, an application rate of about 200 pounds per acre actual methyl bromide will probably be adequate for most nurseries located on light soils. Further studies of application rates on different soil types are needed.

Since the application of Brozone is highly mechanized, up to 6 acres per day can be fumigated, as compared with approximately 1 acre by the standard method. This is very important when the time available for fumigation is limited.

Vapam, at the rate of 50 gallons per acre and covered with polyethylene, also looks promising. At this rate, the treatment is comparable in cost to methyl bromide and it may cost less if application techniques can be improved by using covers several hundred feet long and sealing the edges of the covers with tractor equipment.

The vaporized methyl bromide was as effective as the other methyl bromide treatments but unless the cover-laying device is modified to use 18- to 20-foot covers instead of the present 6- to 9-foot covers, this method appears uneconomical for broadcast fumigation because of the high percentage of overlap between covers. For single-bed treatment, however, the method would be excellent.

From the standpoint of weed control alone, Eptam gave excellent results up to 12 weeks after planting. Some weed control was obtained up to digging time, but the treatment could not be considered effective over the entire growing season. Inasmuch as the first 8 to 12 weeks is the most critical period from the standpoint of mechanical damage from hand weeding, and the cost of the material and application at the 6-pound rate is only about 35 dollars per acre, Eptam could be a very economical treatment.

No adverse effects on the seedlings were noted in any of the treatments. It should be noted here, however, that Eptam at 5- and 10-pound rates has caused some stunting of seedlings in a Georgia nursery. This may have been due to the heavier soil on which that study was conducted, and is a factor to consider when determining the length of time between application and planting.

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EFFECT OF POLYETHYLENE AND REGULAR PACKING METHODS ON PONDEROSA PINE AND DOUGLAS-FIR SEEDLINGS STORED OVER WINTER

Karl B. Lanquist, Nurseryman
J. Henry Doll, Assistant Nurseryman
Mt. Shasta Nursery, Shasta-Trinity National Forests
McCloud, Calif.

Shipping nursery stock without moss or other packing material on the roots permits considerable economy in packing and shipping charges. That it is practical under certain conditions has been shown by Professor John P. Mahlstede's[1] work with ornamental nursery stock shipped completely enclosed in polyethylene bags, and by Duffield and Eide[2] a who successfully packaged Douglas-fir seedlings in such bags with granulated wet peat for 6 weeks or so. We tested its feasibility at the Mt. Shasta Nursery in 1956-57 and in 195859 by contrasting our regular packing method with the method of packaging trees in polyethylene bags without packing material on the roots.

Test Procedures

The packing methods used were as follows:

1. Polyethylene-bag packing. Polyethylene bags were packed with 100 seedlings completely enclosed in each bag. No packing material was used, but seedlings were damp when packed. The bag was sealed with a rubber band.

2. Regular packing. The current packing method used at this nursery is to place the trees in crates with alternate layers of packing material and seedlings. Bunches of trees are laid in the crates with the tops toward the ends of the crates and the roots overlapping in the middle. Packing material is placed on the roots and stems, but not on the needles. The packing material consists of about 50 percent wood shavings and 50 percent vermiculite, well mixed and wet enough to yield a few drops of water when squeezed tightly in the hand. The crate is lined with a water-resistant paper. A space of approximately 2 inches is left in packing between the tops of the trees and the ends of the crates. The packing crates are of slat construction, which provides air circulation and protection to the terminal buds. Large trees may be packed in bales instead of crates.

The trees were stored in our cold storage plant at a temperature of 33 to 34^{0} F. and at a relative humidity of about 92 percent. Pine seedlings can be successfully stored for several months at this temperature and no detrimental mold will develop. Arrangement of trees in storage was such that constant air movement could be maintained on all surfaces of the crates.

The stored trees were planted by planting machines or by regular hand planting. In 1957, weather and growing conditions in the Mt. Shasta area were not favorable, but both improved considerably during the following 2 years.

Observations

In the 1956-57 test, the trees were lifted after November 1, 1956, stored in polyethylene bags for 5-3/4 months by method number 1, and field planted April 27, 1957. Vigorous root and bud activity was noticeable earlier than in trees packed for storage in the regular pack. Field survivals did not differ a great deal between regular-packed trees and bag-packed trees. Each pack method averaged about 85 percent survival.

1Professor John P. Mahlstede has written several articles for The American Nurseryman on shipping evergreens in polyethylene bags.
2Duffield. John W„ and Eide, Rex P. Polyethylene bag packaging of conifer planting stock in the Pacific Northwest. Jour, Forestry 57: 578-579. 1959.

In the 1958-59 test, several thousand trees were packed in polyethylene bags in the fall of 1958 from stock lifted after November 1st when the trees were considered well hardened-off. Bunches of 50 trees were put into polyethylene bags and each bunch was tied with a "Twist-em" in order to keep the bundles intact. Air was pressed out of the bags so that they could be packed. They were tied at the top and no packing material was used. The bags were then packed into crates, 40 bags to a crate. The stock packed in this manner was 1-1 ponderosa pine and 2-0 Douglas-fir. These trees were stored for 5.5 months under the same conditions as in the previous experiments.

Most of the pine trees were planted by machine on a well-prepared site, all brush and other vegetation having been completely removed. The trees were planted in the spring of 1959 on the McCloud District on the Shasta-Trinity Forests. Douglas-fir was planted on the Six Rivers and Klamath Forests. Trees which had been packed in polyethylene bags were planted at about the same time as the trees in the regular pack.

The test planting on the McCloud District was examined in the fall of 1959. Survival percentage from bag pack and regular pack was the same, 94 percent, but the bag-packed seedlings appeared somewhat more vigorous than the others. We did not examine the Douglas-fir plantations, but reports from the Forests indicate that the seedlings packed in polyethylene bags had a 40 percent better survival than those from the regular pack.

Discussions and Conclusions

This study, while not conclusive, indicates the following:

1. Factors other than aeration and wet packing material may be responsible for successful storage. Dr. Henry Hellmers found that there are indications of a relationship of seedling starch content to seedling survival.[3]

2. Pine and Douglas-fir seedlings packaged in polyethylene bags without packing material can be stored for approximately 6 months without noticeable adverse effect on survival or vigor after planting.

We think that the bag-pack method has many advantages over the established packing procedure, especially for long cold storage, for the following reasons: (a) Trees seem to be more vigorous after planting; (b) crates are much lighter to handle; (c) no packing material is needed.

Cost of packaging might be a trifle more for the bag-pack method than for the regular pack method. However, the saving in handling and shipping will outweigh the packaging expense, so that production cost for the two methods will be about the same.

One disadvantage of the bag-pack method is that bag-packed trees are more susceptible to the detrimental effects of the sun and warm temperatures. We made some exposure tests which indicated that trees in polyethylene bags "heated" much faster than trees packed in the regular pack. This problem can, of course, be avoided, but it is of importance and is noted for what it is worth.

3 Dr. Henry Hellmers' unpublished notes dated October 1958 and pertaining to storage problems at the Mt. Shasta Nursery.

REFRIGERATED STORAGE OF NURSERY STOCK

Hugh Wycoff, Nurseryman
Mason State Forest Tree Nursery, Illinois Dept. of Forestry Topeka, Ill.

For the past 6 years the Mason State Forest Tree Nursery at Topeka, Ill., has used refrigerated storage for some of its conifer stock as a means of overcoming the handicaps of labor shortages and inclement weather during the spring shipping season. Trees are dug in early winter and stored under refrigeration for 3 to 4 months, usually from December through February. The amount stored in this manner depends somewhat on lifting conditions during the winter, but as many as a million trees have been successfully carried over. They are also dug as early as possible in spring and stored under refrigeration, or if necessary, for short periods in automatic fan-controlled, air-cooled storage rooms. Spring storage of this type presents no problems and lasts from a few days to a few weeks. In this way, Mason State nursery can ship over six million trees in less than 5 weeks in the spring.

The trees are stored in square metal containers lined with wet moss, or are packed ready for final shipment. The shipping packages used were originated in Illinois. A woven wood veneer mat, 26 by 30 inches, is wrapped around 1,000 trees that are packed in wet moss, roots overlapping in the center. The wrapper is rolled around the trees by an ingenious machine, forming a cylindrical bale from 9 to 11 inches in diameter, and weighing from 30 to 50 pounds.

Moisture loss has been the major problem encountered with prolonged storage of trees in such bundles. It is quite rapid at first but soon decreases and the packing material remains moist almost indefinitely. To compensate for this loss, we irrigate the bundles once a month by thrusting a pointed, perforated tube on the end of a hose into their centers.

Humidity must be maintained at a high level in such storage, a difficult thing to do because water condenses out on the cooling coils. We have no way to control humidity, other than by natural evaporation from the stored bundles and from water occasionally sprinkled on the walls and floor. The problem is less difficult when the storage room is filled nearly to capacity.

Mold has not been a serious problem at a storage temperature of 32 to 34^0 F. No mold develops on the conifer seedlings if they are alive, but some white mold develops on dead material and on the wood veneer mats over a period of several months. Sometimes the mats are dipped in copper naphthenate. Vancide and captan seem to give some control of mold on hardwoods. A slightly lower temperature would probably help control the mold still further.

The storage room has 865 square feet of floor space and a 10-foot ceiling. It has been filled to capacity only twice in 6 years. Data is lacking as to the minimum needs of open space for air circulation. The racks available permit the bundles to be placed two layers deep on slatted 2 by 4 shelves. When the racks are filled, the aisles are bridged and loaded in the same manner. Care is taken to leave air space on all sides of each bundle.

The storage building is in abasement of the packing shed. It is insulated with 4 inches of cork and cooled by two Copeland Model LH combination air and water cooled, hermatic type, 3 hp., 3-phase compressors. There are two unit coolers with a unit capacity of 1,000 B.t.u. per hour 1^0 T.D. These are operated by separate 2-pole thermal switches and magnetic solenoid valves on the liquid lines. The unit coolers have constant fan operation and water defrost. As a precaution against mechanical trouble in an area that has limited repair service, two units were installed instead of one. Since one unit is ordinarily enough to hold the desired temperature, defrosting is done by alternating the use of the two coolers.

Storage is a very important and sensitive part of the operation at this nursery. It is probably very important that the stock be completely dormant when placed in winter storage. Nothing is put into winter storage until after December 1st.

Customers have been naturally hesitant to accept winter-stored stock and the nursery has been hesitant to institute it as standard practice, but results have been very satisfactory during the 6 years it has been tried. The only failure reported to date was with some jack pine lifted in October and stored over winter. They looked good in the spring, but failed to grow.

The accumulated experience of the nursery and customers shows that refrigerated storage permits earlier distribution and planting than would otherwise be possible. It is especially helpful in filling southern and sand-area orders before stock can be lifted in the spring.

The following references have been found helpful in studying the p r o b 1 e m of refrigerated storage:

Chemical Treatment of Nursery Stock for Better Storage, W.P. Trampe, Ohio Nursery Notes, Vol. 29, No. 1.
Refrigerated Storages, K. Bradley, American Nurseryman, Sept. 1, 1959.
Strawberry Plant Storage Using Polyethylene Liners, Worthing and Scott, American Nurseryman, May 1, 1957.
Refrigerate Your Nursery Stock, Michigan State University Nursery Notes, No. 1954.
Refrigerated Storage of Conifer Seedlings in the Pacific Northwest, F. W. Deffenbacher, Journal of Forestry, Dec. 1959.
The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks, U.S.D.A. Ag. Handbook No. 66.

STORAGE OF BARE ROOT CUTTINGS OF SELECTED ORNAMENTALS

Fred B. Widmoyer Associate Professor of Horticulture
University of Connecticut
Storrs, Conn.

These tests have been conducted to determine suitable storage conditions for ornamental crops. Selected fungicidal and bacteriacidal compounds were used in an effort to reduce growth during periods of storage.

Nine species of plants were tested: Taxus cuspidata, Juniperus virginiana, Buxus sempervirens, Deutzia lemoinei, Weigela floribunda, Forsythia fortunei, Abelia grandiflora, Hydrangea paniculata, and Azalea sp. These plants had been rooted from either ha6d or softwood cuttings, placed in nonperforated polyethylene bags, and stored at 32 and 40 Fahrenheit. Chemicals used to control storage molds were sodium o-phenylphenate .25 percent, borax 8 percent, karathane 1 percent, captan 5 percent, and Diphenyl-impregnated filter paper with.08 percent. The cuttings were placed in storage on October 16, and removed from storage on February 23 and April 19, at which times they were plotted and carried into the greenhouse to determine the number that would survive.

All plants stored with borax and thiourea failed to survive. Higher survival rates were found among those plants in which phenyl-phenate, biphenyl, karathane, and captan were used as the fungicides. Highest survival rates were found in those containers in which biphenyl was used as the fungicide. Plants stored at 40° were superior to those plants held at 32°. Stored plants failed to make growth comparable to that of the untreated plants.

On the basis of these experiments, storage of cuttings over a long period of time is not recommended. Some plants were particularly sensitive to the materials used for storage, and others failed to survive even though chemicals were not used. Hedera helix baltica failed to survive storage under any condition.