Tree Planter's Notes, Vol. 34, No. 4 (1983)

Intermittent-Furrow Tree-Planting Machine Evaluation

Dan W. McKenzie, Raymond Merala, and Alan Alsobrook
Mechanical Engineer and Agricultural Engineer, USDA Forest Service, Equipment Development Center, San Dimas, Calif.; and Forester/Silviculturist, Strong River Ranger District, 8ienville National Forest, Raleigh, Miss.

A commercially available intermittent-furrow mechanized planter was evaluated, based on established performance criteria, to gain field experience data on mechanized planting. The planter tested met most of the criteria.

Figure 1.—*Marden Spot Planter, Model 100.*

During the winter of 1981, an intermittent-furrow tree-planting machine was evaluated by the San Dimas Equipment Development Center (SDEDC). The evaluation was performed on the Bienville National Forest, Strong River Ranger District, Raleigh, Miss., using the Marden Spot Planter, Model 100 (fig. 1). The Model 100 is produced by the Marden Manufacturing Co., Inc., Auburndale, Fla.

The Model 100 is mounted on a two-wheeled carrier, which can be towed by a rubber-tired or crawler tractor, and weighs 5,400 pounds. The planter is capable of planting both bare-root and containerized stock. The planter's height above ground is adjusted by means of a turnbuckle. The planting mechanism can be powered by the hydraulic pump on the towing tractor or by a power takeoff pump driven by the tractor's engine.

The Model 100 operator sits in the planter facing to the rear and manually loads seedlings. The planting sequence is initiated by depressing a foot pedal switch, which actuates the solenoid hydraulic valve and causes the planting arm to move downward. When the planter moves forward, the hollow dibble forms a furrow into which a seedling is injected. The packing wheel then firmly plants the seedling. The arm returns to the reload position when the pedal switch is released. The total cycle time to load, lower the planting arm, eject and pack the seedling, and return the planting arm so it is ready again to be loaded is 31/z to 4 seconds. The prime mover for the planter was a John Deere (JD) 550crawler tractor, usually used by the District to pull afire plow.

The Model 100 Spot Planter was used to reforest 136 acres in small, scattered parcels. Loblolly pine *(Pinus taeda)* was planted on 8- by 8-foot spacings at 681 seedlings per acre, with minimum acceptable stocking established at 300 well-distributed seedlings per acre. All loblolly seedlings were 1-0 bare-root stock. In addition, a 35-acre sheared and windrowed site with droughty, sandy soils was planted with longleaf pine (P. *palustris)* on a5- by 8-foot spacing, giving 1,089 seedlings per acre. Minimum acceptable stocking was established at 600 well-distributed seedlings per acre. Longleaf seedlings were also 1-0 bare-root stock.

The field evaluation was based on a performance criteria for an intermittent tree planter developed by SDEDC in cooperation with the Forest Service, Southeastern Area

State and Private Forestry, and approved by the Forest Regeneration Committee, which is chaired by a member of the Forest Service, Timber Management Staff, Washington Office.

The planter planted well while turning and is able to plant up and down slopes without creating furrows that would be washed out during an intense rainfall. The planter met the packing criterion.

The planter was pulled, without difficulty, by the JD 550 crawler tractor weighing 15,500 pounds. The maximum pull, with the dibble in the ground, was 4,500 pounds, with a mean pull of 3,000 pounds.

The average measured instantaneous production rate was 952 seedlings per hour with a standard deviation of 70. When this instantaneous rate is reduced by a field efficiency of 80 percent, the sustained planting rate becomes 762 seedlings per hour.

The planter cost was $9,995, which was well below the price of $19,535 given by the affordability equation developed by SDEDC.

This affordability equation is based on parametric cost estimating. Two parametric values are used: (*1*) Cost of hand planting (the next best alternative) and (*2*) machine production or planting rate. The equation for a towed tree planter is:

$$X = -\$67{,}500 + [(1{,}203)\,(HPC)\,(MPR)]$$

Where X = Maximum affordable tree planter purchase price.

HPC = Hand planting cost in dollars per seedling.

MPR = Machine production rate in seedlings per hour.

For more information on the development of this affordability equation, obtain Project Record 8124 1203 entitled "Tree-Planting Machine-How Much Can You Afford to Pay for One?" from SDEDC.

Season-long records of planter production, operating time, breakdowns (failures), and repair time were kept to determine reliability (how often it breaks), availability (percentage of time operating), and maintainability (how long it takes to fix when it breaks). Reliability was 4,035 cycles per failure. Availability was 67 percent. Maintainability was 2.34 hours per failure.

No significant safety problems with the Model 100 were observed or reported during the season-long field tests on the District. The planter has a rollover-protected operator's station, which is judged to be both more comfortable and safer than those usually found in conventional continuous-furrow tree-planting machines. In the Model 100, the operator enters from the left side, over the planting arm, and can sit erect since there is no need to place the seedlings directly into the ground. The operator uses a horn to communicate with the tractor operator.

The results of the evaluation were reported in a July 1982 Project Record 8224 1201, "Evaluation of an Intermittent-Furrow Tree-Planting Machine," issued by SDEDC.

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Fungicide Control of Algae in Containers

William H. Pawuk
Plant Pathologist, USDA Forest Service, Tongass National Forest, Stikine Area, Petersburg, Alaska[1]

The fungicides maneb and dichlone controlled algae in styroblock containers in the greenhouse. Treatments were nontoxic to shortleaf pine seedlings.

Many blue-green and green alga species form on soil in containers used for growing containerized southern pine seedlings (*1*). When algae dry, a crust develops, creating a barrier that interferes with irrigation, fertilization, and pesticide applications (*2*).

Chemicals that control algae in water are not labeled for soil treatments, so the greenhouse manager has no guidelines for selecting appropriate chemicals for soil treatments. During greenhouse disease control studies, suppression of algae development was noted by certain fungicidal treatments. A screening study was then established, and 11 materials were evaluated for controlling algae on soil in styroblock containers used to grow shortleaf pine (*Pinus echinata* Mill.). After the screening test was completed, a second study was installed to refine application rates for the most effective chem.-icals.

[1]Research was conducted while the author was assigned to the USDA Forest Service, Southern Forest Experiment Station, Pineville, La.

Methods

Study I. Individual cavities in styroblock containers are circular, 2.5 centimeters in diameter, and 10.2 centimeters deep. Cavities were filled with a peat-lite medium (Jiffy Mix), watered, and planted with shortleaf pine seed germinants. From 2 weeks after planting, each time the seedlings were irrigated, they were also fertilized with Peters Peat-Lite 20N-19 P-18 K water soluble fertilizer at the rate of 150 parts per million nitrogen (N). Chemical treatments were applied immediately after the first fertilization and 4 weeks later. All chemicals were applied in water at 1 milliliter per cavity, but not as a foliar spray.

The following substances were tested: Simazine (2-chloro-4, 6-bis (ethylamino)-5-triazine), dichlone (2,3-dichloro-1, 4-napthoguinone), maneb (manganese ethylene bis dithiocarbamate), Bordeaux mixture (equal parts copper sulfate and calcium hydroxide), cutrine (copper citrate and copper glucinate chelates), captan (N-trichloromethylthio-4-cyclohexene-1-2 dicarboximide), Clorox (5.25 percent sodium hypochlorite), sulfur (wettable dusting sulfur, 95-percent pure), zineb (zinc ethylenebisdithiocarbamate) copper sulfate, and Kocide 101 (cupric hydroxide) (table 1).

The screening study was established as a split-plot design with four randomized complete blocks

Table 1.—*Algae development after 10 weeks, under varying fungicide treatments*

Treatment	Algae development'			
Concentration 2	0.02	0.03	0.04	0.05
Simazine	.8	.0	.0	.0
Concentration	.1	.2	.3	.4
Dichlone	1.8	1.2	.8	.5
Maneb	2.8	1.2	.8	.2
Bordeaux mixture	4.0	3.0	2.0	.8
Captan	2.5	3.2	3.2	2.8
Sulfur	3.0	3.2	3.5	3.8
Zineb	3.5	4.0	3.8	3.8
Copper sulfate	4.0	4.0	3.8	3.8
Kocide 101	4.0	4.0	4.0	4.0
Concentration	.5	1.0	1.5	2.0
Cutrine	2.5	3.5	2.0	1.8
Clorox	3.2	3.0	2.5	3.2
Check		3.9		

[1]Algae development based on the following rating: 0 = no algae present, 1 = algae present but barely detectable, 2 = algae forming a pale thin film, 3 = algae forming a thin mat less than 0.5 millimeter thick, 4 = algae forming a thick mat greater than 0.5 millimeter thick.
[2]Concentrations in milligrams per square centimeter

Each treatment was applied to one cavity in each replication. At 10 weeks, algae control was estimated on a scale of 0 to 4, with 0= no algae present, 1 = algae present but barely detectable, 2 = algae forming a pale green film, 3 = algae forming a thin mat less than 0.5-millimeter thick, and 4 = algae abundant forming a thick mat greater than 0.5 millimeter.

Study II. Maneb and dichlone were selected from the screening tests for further evaluation. Culture was identical to that in the screening study, except that seedlings were established by sowing, and treatments and controls were evaluated after 13 weeks. Dichlone and maneb were applied as a single drench at 0.4, 0.6, 0.8, and 1.Ormilligram of active ingredient per square centimeter at either 3 or 5 weeks after sowing. They were also applied at half concentration (0.2, 0.3, 0.4, and 0.5) at 3 and 8weeks (table 2). The total amount applied was the same for the single drench. A check (untreated) treatment was included.

This study was established in a randomized complete block design with four replications. Each treatment replicate comprised 10 seedlings. Average height and dry weight of the seedlings in each treatment replicate were determined after 13 weeks.

Table 2.—*Algae development and shortleaf pine seedling growth in containers at 13 weeks drenched with maneb and dichlone*

Variables	Algae development	Seedling height	Seedling dry weight
	Rating[1]	*Cm*	*Mg*
Material[2]			
Control	2.7	14.5c[3]	412c
Maneb	1.5	16.7a	528a
Dichlone	1.9	16.0b	474b
Time applied[4]			
Week 3 and 8	1.6b	16.4a	505a
Week 3 only	1.8a	16.4a	512a
Week 5 only	1.7b	16.2a	486a
Drench rate (mg/cm 2)[2]			
0.4	2.0	15.8b	489a
.6	1.7	16.4ab	502a
.8	1.6	16.7a	508a
1.0	1.5	16.6a	505a

[1] Algae rating: 0= no algae present, 1 =algae present but barely detectable, 2=algae forming a pale green film, 3 = algae forming a thin mat less than 0.5 millimeter thick, and 4 = algae forming a thick mat greater than 0.5 millimeter thick.

[2] An interaction among drench rates and materials occurred in the algae development data. Maneb was better than dichlone at the 0.8- or 1.0-milligram rates, but not at the others.

[3] Mean separation in columns for treatment variable groupings by Duncan's multiple range test (P=0.05).

[4] Maneb and dichlone applied as a single drench.

Results

Study I. Algae formed a thick mat on soil in control plots and many treatment plots. Simazine gave the best control, but was toxic to shortleaf pine seedlings at all levels tested (table 1). Bordeaux mixture, dichlone, and maneb gave good control at one or more concentrations and were not phytotoxic. Dichlone and maneb were more effective than Bordeaux mixture at low concentrations and were selected for further testing.

Study II. Both maneb and dichlone reduced algae development (table 2). Algae control was better when fungicides were applied at 3 and 8 weeks or at 5 rather than at 3 weeks. There was an interaction between amount applied and fungicide. Maneb was better than dichlone at 0.8 or 1.0 milligram, but not at0.4or0.6 milligram. At each drench schedule, algae development decreased as maneb concentration increased. This trend was not present in the dichlone treatments.

Drenching increased height growth over the check treatment. Seedlings drenched with maneb were significantly taller than those drenched with dichlone, but they differed by only 0.7 centimeter. Height growth was unaffected by drench schedule, but was affected by amount of chemical applied. Seedlings from the 4-milligram treatment were smaller than those from the 0.8- or 1.0-milligram treatment. None of the other treatments differed from each other.

Drench schedule or rate did not affect seedling dry weight, although all treatments resulted in heavier seedlings than the check. Seedlings drenched with maneb were larger than seedlings drenched with dichlone.

Discussion

Several chemicals were evaluated for their effectiveness in controlling algae on media surfaces, and possible toxicity to pine seedlings. Maneb and dichlone were the most effective of those materials tested. Neither maneb nor dichlone inhibited the growth of shortleaf pine seedlings when applied to the soil surface, and growth was greater in many treatments than in checks. The increase in growth may have been from chemical protection of seedlings from pathogenic soil fungi or from more efficient water and nutrient infiltration when algae is controlled. From a practical viewpoint, any treatment giving control at 2.0 or better (algae forming a pale green film to none present) would be operationally satisfactory.

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Tree Planter's Notes, Vol. 34, No. 4 (1983)

Sporotrichosis—A Disease Hazard for Nursery Personnel and Tree Planters

Darroll D. Skilling
Principal Plant Pathologist,
USDA Forest Service, North Central Forest
Experiment Station, St. Paul, Minn.

Nursery workers should be aware of the potential for contracting sporotrichosis and the symptoms of this disease. The author relates his personal experience with the disease and suggests how to avoid infection.

Nursery workers, tree planters, and gardeners should be aware of possible exposure to a potentially serious fungus disease sometimes contracted by those working with soil or, most particularly, with trees packed in sphagnum moss. This disease, called sporotrichosis, is a lymphatic disease in people and animals and is caused by the fungus *Sporotrichum schenckii.* This fungus has been found in soil, on flowers and shrubs, and even on wooden mine props. It is also associated with the sphagnum moss used to keep tree roots moist during shipment and storage.

How or when the moss becomes contaminated is not clear. Attempts to isolate the fungus directly from sphagnum bogs have usually failed, but *S. schenckii* has been recovered from bales of moss newly arrived at a nursery site (*1*). The fungus seems to increase in the moistness of most packing sheds. In one case, a mixture of soil and sphagnum remaining in the shed may have served as a reservoir for the fungus the following year (*2*).

The fungus is found throughout the United States, but it appears to be most common in the Midwest, especially in Wisconsin. Several outbreaks in other States have been traced to sphagnum moss shipped from Wisconsin (*1*). Because of periodic outbreaks of sporotrichosis, the State forest tree nurseries in Wisconsin no longer use sphagnum moss for packing seedlings. Several workers in the USDA Forest Service nursery in Michigan also contracted sporotrichosis and that nursery also discontinued the use of sphagnum moss. No cases of sporotrichosis have occurred at any of these nurseries since they stopped using sphagnum moss as packing material.

Infection occurs when the spores of the fungus are introduced through a small abrasion or scratch in the skin. In 1 to 4 weeks. a small painless blister develops at the entry court. This blister becomes inflamed and slowly enlarges. Other areas may become infected as the fungus spreads through the lymph vessels. Nodules may form along the infected lymph channels, and the lymph glands in the armpit or elbow may become enlarged and sore. If untreated, the disease progresses slowly to the bones, abdominal organs, and uninvolved skin. But diagnosed early, the disease can be adequately treated and is rarely fatal (*1*).

I contracted sporotrichosis several years ago while planting seedlings that had been packed in sphagnum moss. A small blister appeared on my wrist about 3 weeks after I had worked with the moss. This blister broke open in a few days but did not heal. Within the next 2 weeks, the resulting sore enlarged and my wrist became tender. A few days later I noticed a red streak spreading from the infected area toward my elbow. At this point, I had visions of blood poisoning and quickly headed for my family physician. He prescribed antibiotics, but unfortunately they are not effective against fungus diseases. A week later my symptoms were more severe with greater pain throughout my entire arm. I then went to another physician who also had difficulty in diagnosing the problem. Later that same day, a colleague in forest disease research suggested the possibility of sporotrichosis. He had seen a flyer on this disease put out by the Forest Service a few months earlier. Armed with this flyer, I returned to my physician and between the two of us we were able to isolate the fungus on Sabouraud's agar from the open ulcer. At this point I began the treatment for sporotrichosis, which is potassium iodine taken orally several times a day. My lesion healed in about 2 months, but I continued taking potassium iodine for 3 months after healing. This treatment, while cheap and effective, may cause some discomfort. I endured a perpetual upset stomach while taking potassium iodine and still have some stomach problems today as a result of this treatment. But not all patients have such problems.

Other than the possible side effects of the treatment, the biggest problem with sporotrichosis is delayed diagnosis. Many physicians are not familiar with this disease. In my case, after we had isolated the fungus from the open lesion, my physician sent me to a prominentskin specialist in Minneapolis to confirm our diagnosis. This specialist and his colleague both stated that I did not have sporotrichosis. Nevertheless my physician and I continued the treatment and later the Minnesota State Health Department confirmed our diagnosis.

One way to avoid sporotrichosis is not to handle trees that are packed in sphagnum moss. (This is my policy.) If you must work with such trees, be careful: wash your hands frequently and treat lacerations and abrasions promptly. Nursery workers and tree planters who develop sores that do not heal properly should promptly seek medical attention and tell their doctors about the possibility of sporotrichosis.

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Tree Planter's Notes, Vol. 34, No. 4 (1983)

Removing Cull Acorns From a Water-Willow Oak Acorn Lot Using Salt Solutions[1]

G. R. Johnson, Jr.
Graduate Research Assistant,
North Carolina State University, Raleigh

Upgrading water-willow oak acorn lots by flotation in a salt solution is superior to flotation in water or no flotation at all.

The percentage of sound acorns in water-willow oak acorn lots can usually be increased by floating off the culls in water. A majority of cull acorns float to the top where they can be removed, but acorns with partially decayed cotyledons sometimes sink to the bottom where they mix with the sound acorns. If an acorn lot is collected after a wet autumn, cull acorns may not float because they are saturated with water. In an effort to find a more effective method of removing cull acorns, a study was initiated to examine the feasibility of floating acorns in salt solutions of varying densities. Although sycamore and yellow-poplar seedlots have been upgraded by separating out seeds of lower density on a gravity separator (1, 2), use of a gravity separator on acorn lots is impractical for nursery personnel. However, flotation in a salt solution is simple and can be done with minimum equipment.

Procedure

Water-willow oak acorns were obtained from a collection made in November by Union Camp Corp., Franklin, Va. The seeds were stored in sealed plastic bags at 3° C. and 98-percent relative humidity from the time of collection until the study was initiated the following April. One-half of the seedlot was soaked in water for 4 days to saturate and sink all acorns. The remaining half was retained in the condition common to storage.

For each acorn lot, acorns were placed in 700 milliliters of water, and salt (NaCl) was added in 30-gram increments. At the start and after each addition of salt, acorns that floated were classified as decayed, partially decayed (some yellow cotyledon present), and sound (cotyledon completely yellow) .

After examination of the data, a specific ratio of salt to water that would remove most of the culls and leave a high percentage of the sound acorns was chosen. For the unsaturated lot, 230 grams of salt per liter was chosen; and for the water-saturated lot, 285 grams of salt per liter was chosen. Additional saturated and unsaturated acorn lots were floated in water and in the specified salt solution as a test. All acorns were then cut and classified for viability.

Results and Discussion

Unsaturated acorn lot. The results of floating 87 unsaturated acorns in various concentrations of salt solutions are summarized in table 1. Eight fully decayed acorns floated immediately in tapwater. After 60 grams of salt were added, two more fully decayed and one partially decayed acorn floated. At this point, all the fully decayed acorns had been removed, but 93 percent of the partially decayed acorns had not floated. After 150 grams of salt were added, 25 percent (four) of the partially decayed acorns floated. The addition of more salt floated both partially decayed and sound acorns.

No sound acorns were floated from the addition of 150 grams of salt, but 13 percent (eight) of the sound acorns floated after 180 grams of salt were added. To try to maximize the number of floating cull acorns and minimize the number of floating sound acorns, a solution of 230 grams of salt per liter of water (160 g/700 ml) was used to separate another randomly chosen, unsaturated acorn lot of 236 acorns (table 2).

When the acorn lot was floated in water, the percentage of sound seeds increased from 83 to 88 and no sound seeds were lost. When the same acorn lot was floated in the salt solution, the percentage of sound seeds increased to 93 with only 2 percent of the sound seeds removed.

[1]Paper number 8718 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh.

Floating acorns in water increased the percentage of sound seeds by 5, and an additional 5-percent increase was obtained by floating acorns in the salt solution.

Water-saturated acorns. The results of floating 92 water-saturated acorns in various salt solutions are summarized in table 3. Neither decayed nor sound acorns would float after 0 to 75 grams of salt were added. After 105 grams of salt were added, the decayed acorns began to float. After the addition of 195 grams of salt, all fully decayed acorns (three) and 43 percent (three) of the partially decayed acorns floated. When 225 grams of salt were added, two more culls floated, but 13 percent of the sound acorns had floated as well.

Two hundred eighty-five grams of salt per liter of water (200 g/700 ml) floated a large percentage of cull acorns without floating many viable acorns. No acorns floated in tapwater, so the salt solution was the only way to remove the culls. By floating acorns in the salt solution, the percentage of sound seeds was increased from 81.5 to 93 with a loss of only 2.5 percent of the sound acorns (table 4).

Table 1.—*Unsaturated acorns floated using various amounts of salt (NaCl) in 700 milliliters of water*

Grams of salt added	Floating acorns: Decayed	Floating acorns: Partially decayed	Floating acorns: Sound	Nonfloating acorns classified sound
				%
0	8	0	0	77
30	1	0	0	78
60	1	1	0	80
90	0	0	0	80
120	0	2	0	82
150	0	1	0	84
180	0	3	8	85
210	0	3	18	85
Nonfloating acorns after 210 grams NaCl added	0	6	35	—[1]
Total in acorn lot	10	16	61	—

[1]– = not applicable.

Table 2.—*Acorn counts after flotation in 230 grams of salt per liter of water for an unsaturated seedlot*

	Floating acorns: Decayed	Floating acorns: Partially decayed	Floating acorns: Sound	Nonfloating acorns classified sound	Sound seeds lost by floating
				%	%
In water	15	0	0	88	0
In salt solution	20	7	4	93	2
Remaining acorns	1	13	191	—[1]	—
Total	21	20	195	—	—

[1]– = not applicable.

Conclusion

Floating cull acorns in water is not a thorough and sometimes not a feasible way to separate cull and sound acorns, especially if the acorns are water-saturated. By using a salt solution, more cull acorns can be removed. For water-saturated acorns, where no acorns float in water, a salt solution can float a large proportion of the cull acorns and still remove very few sound acorns. Because this can be done quickly and acorns can be washed clean of salt almost

Table 3.—*Water-saturated acorns floated using various amounts of salt (NaCl) in 700 milliliters of water*

Grams of salt added	Floating acorns: Decayed	Floating acorns: Partially decayed	Floating acorns: Sound	Nonfloating acorns classified sound
				%
0 to 75	0	0	0	89
105	2	0	0	91
135	0	1	1	92
165	0	0	1	92
195	1	2	2	95
225	0	2	7	97
255	0	1	24	98
Nonfloating acorns after 255 grams NaCl added	0	1	47	—[1]
Total in acorn lot	3	7	82	—

[1]– = not applicable.

Table 4.—*Acorn counts after flotation in 285 grams of salt per liter of water for water-saturated seeds*

	Floating acorns: Decayed	Floating acorns: Partially decayed	Floating acorns: Sound	Nonfloating acorns classified sound	Sound seeds lost by floating
				%	%
In water	0	0	0	81.5	0
In salt solution	16	14	5	93	2
Remaining acorns	2	12	188	—[1]	—
Total	18	26	193	—	—

[1]– = not applicable.

immediately, the remaining acorns should not be damaged by the salt solution.

For unsaturated acorns stored at 3° C. and 98-percent relative humidity for 5 months, a solution of 230 grams of salt per liter of water is recommended for separation. Tests indicate this solution can increase the percentage of sound seeds by an additional 5 percent over water flotation. Separation of water-saturated acorns can be best accomplished by floating them in a salt solution of 285 grams of salt per liter of water. This gave an 11-percent increase in the percentage of sound seeds.

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The Effects of Seedbed Density and Fertilization on 1-0 White Oak Nursery Stock

James R. Wichman and Mark V. Coggeshall
Nursery Forester and Tree Improvement Forester, Indiana Department of Natural Resources, Vallonia Nursery, Vallonia, Ind.

Average seedling caliper for white oak increased as seedbed density decreased. Fertilizer treatments did not influence seedling caliper. Seedling height was not influenced by density or fertilizer. Percentage of culls increased as seedbed density increased, but was not influenced by fertilizer.

White oak (*Quercus alba*) is one of our most valuable tree species for both timber and wildlife. Interest in planting white oak has increased over the past decade as the value of white oak timber has increased. Although more trees are being planted, many of these plantings have not been successful (*2*).

Information on the best nursery cultural practices to produce high-quality white oak seedlings is not available. For oaks in general, recommendations for seedbed density range from 10 to 30 seedlings per square foot (*5*).

The purpose of this study is to measure the effects of seedbed density and fertilizer treatments on height, caliper, and percentage of cull for 1-0 white oak nursery stock. A second objective of this study is to measure the effects of the density and fertilizer treatments on growth and survival after the trees have been planted in the field. Results from this part of the study will be reported at a later date since this information will not be available until the trees have been in the field for a period of time.

Methods

The seedbed area used for this study was treated according to stardard nursery practices for growing hardwoods at the Vallonia Nursery. The soil type was an Alvin sandy loam. In May 1980, a cover crop of Sorghum-Sudan was sown and fertilized with 1,000 pounds per acre of 12-12-12 fertilizer. In May 1981, the residue from the cover crop was plowed under and the area fertilized with 800 pounds per acre of 6-24-24. The area was maintained in a fallow condition until August 1981, when it was fumigated with 450 pounds per acre of methyl bromide.

White oak seeds were collected in southeastern Indiana from a wide variety of sources and thoroughly mixed before sowing so that the results from the study would be applicable to a wide range of seed sources. The seed was sown by hand in October 1981 in five 1-inch-deep drills spaced 8 inches apart on a standard 4-foot-wide nurserybed. The seed was covered with ½ to 1 inch of soil and mulched with 2,000 pounds per acre of hydromulch.

Treatments consisted of three seedbed densities of 4, 8, and 12 seedlings per square foot and three top-dress fertilizer rates of 0, 400, and 800 pounds per acre of 12-12-12 fertilizer at each level of seedbed density. The study was designed as a 3-by-3 factorial arranged in a randomized complete block design having three replications. The nine treatment combinations were assigned at random to each replication and were represented by a 4-by 4-foot plot.

Density treatments were sown at 12, 24, and 36 seeds per square foot assuming a survival percentage of 33 percent. All plots were thinned to the correct density in June 1982. Fertilizer treatments were applied by hand in June and July 1982 in 400-pound-per-acre increments and at 2-week intervals.

In January 1983, the seedlings were lifted and measured to determine height, caliper (diameter 1 inch above the root collar), and percentage of cull. A cull was considered to be any seedling with a caliper of less than 1/8 inch (3.2 mm) and a height of less than 6 inches (15.2 cm). The data were subjected to an analysis of variance. Percentage of cull data was transformed by the arcsin percentage transformation before the data were analyzed. Measurements were made on 3,750 seedlings.

Results and Discussion

Seedbed density significantly influenced seedling caliper (table 1). Average seedling caliper increased from 3.1 millimeters at a seedbed density of 12 seedlings per square foot to 4.1 millimeters at 4 seedlings per square foot (table 2 and fig. 1). Average caliper at 12 seedlings per square foot was slightly less than the minimum size for a shippable seedling (3.2 mm or 1/8 in); whereas at a seedbed density of 4, the average caliper was well above the minimum size. Although the average caliper at 12 seedlings per square foot was less than 3.2 millimeters, only 28 percent of these trees were in the cull category. The explanation for this apparent contradiction was that the caliper of the culls was so small that it lowered the average (mean) caliper for the treatment to 3.1 millimeters (table 2). Also, many of the non-cull seedlings were only slightly larger than the minimum size for a cull. Studies with other species have shown that large-caliper seedlings are more likely to survive and grow when outplanted (*3, 6*). If this holds true for white oak, the large caliper seedlings grown at low seedbed densities would be better planting stock. Barham (*1*) studied the effects of seedbed density on cherrybark oak *(Quercus falcata* var. *pagodaefolia)* and recommended a seedbed density of 4 seedlings per square foot for producing the maximum number of high-quality seedlings.

Table 1.—*Analysis of variance of caliper, height, and cull seedling percentage for 1-0 white oak*

Source of variation	df	Mean square for: Caliper	Height	Cull seedling percentage
		Mm	*Cm*	*Arcsin √percent*
Blocks	2	0.2107	4.7660	22.6248
Density (D)	2	2.3652**	7.6515	273.6415**
Fertilizer (F)	2	.0363	4.1160	28.4193
D *X* F	4	.0285	2.1981	15.9504
Error	16	.0582	5.6384	12.2361

** = significant differences at $P \leq 0.01$.

Table 2.—*Average caliper, height, and cull seedling percentage by seedbed density and fertilizer treatments for 1-0 white oak*

Treatments	Caliper	Height	Cull seedling percentage
	Mm	*Cm*	*%*
Density (seedlings/ft^2)			
4	4.1a[1]	25a	13a
8	3.4b	24a	19b
12	3.1c	23a	28c
Fertilizer (lb/acre)			
0	3.4a	24a	21a
400	3.5a	25a	21a
800	3.6a	24a	17a

[1]Means within a column not followed by a common letter are significantly different at $P \leq 0.01$.

In contrast to seedbed density, fertilizer treatments did not affect seedling caliper (tables 1 and 2). Apparently the nursery soil was able to supply the nutrient requirements of white oak without the need for additional fertilizer. The white oak seedlings had a large, deeply penetrating root system, which may have been able to extract nutrients from a large volume of soil.

For seedling height, neither seedbed density nor fertilizer treatments had any significant influence (tables 1 and 2). Shipman (4) studied the effects of seedbed density on height growth of 1-0 white oak and also found that density did not influence height growth.

The cull seedling percentage was significantly influenced by seedbed density, but not by fertilizer treatments (tables 1 and 2). The percentage of culls increased from 13 percent at 4 seedlings per square foot to 28 percent at 12 seedlings per square foot (table 2). The effect of seedbed density on percentage of culls relates

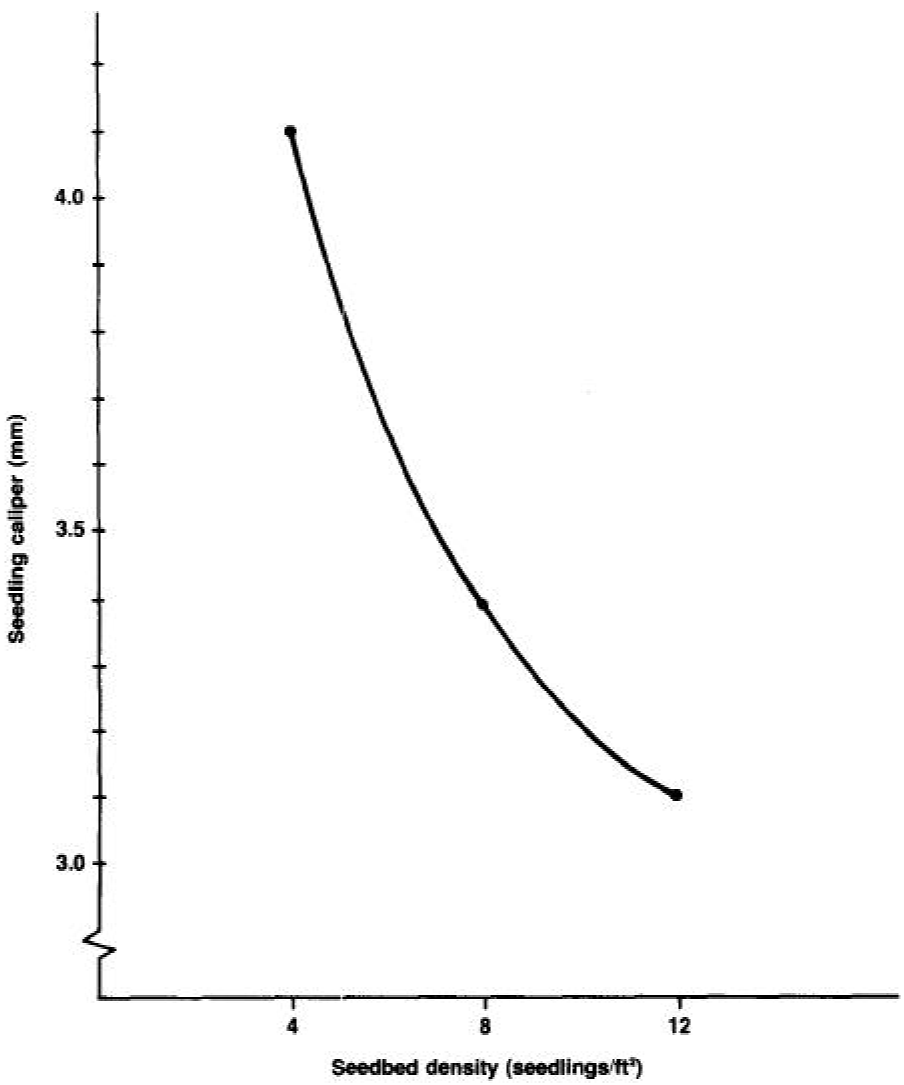

Figure 1.—*The relationship between seedling caliper and seedbed density for 1-0 white oak.*

directly to costs of growing seedlings in the nursery. Table 3 shows the estimated cost for bedspace and seeds for producing white oak at the Vallonia Nursery. Costs are shown in units of dollars per 1,000 shippable seedlings. Bedspace cost included fumigation, tillage, and fertilization and the labor for these presowing operations. Bedspace cost was estimated at $0.04 per square foot. Seed cost included all seed collection costs and was estimated at $20 per 1,000 ungraded seedlings.

Seed cost increased as seedbed density increased because the percentage of culls increased. Bedspace cost decreased as seedbed density increased because more seedlings were grown per square foot (table 3). For total cost, a seedbed density of eight seedlings per square foot resulted in the lowest cost. However, cost at the three densities did notdiffer greatly. If the large white oak seedlingsare more likely to survive and grow when planted in the field as noted previously, then the larger seedlings could be grown at low seedbed densities without significantly increasing production cost.

When seed is scarce (a frequent situation), low bed densities will produce the maximum number of shippable seedlings per unit of seeds. The relationships shown in table 3 would change if different values for seed or bedspace cost were used.

Table 3.—*Bedspace, seed, and total cost for 1-0 white oak as related to seedbed density and cull seedling percentage*

Seedbed density	Cull seedling percentage	Bedspace cost	Seed cost	Total of bedspace and seed cost
Seedlings/ft²	*%*	*Dollars per 1,000 shippable seedlings*		
4	13	11.60	23.00	34.60
8	19	6.20	24.70	30.70
12	28	4.60	27.80	32.40

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English Oak Grows Better Than White Oak of Comparable Seedling Size[1]

Knud E. Clausen

Principal Plant Geneticist, USDA Forest Service, North Central Forest Experiment Station, Forestry Sciences Laboratory, Carbondale, Ill.

Large-grade seedlings of English and white oak survived better than those of medium grade and small grade. English oak averaged 24-percent taller than white oak at age 8, but height was related to seedling size in both species.

Thirteen-year-old English oak (*Quercus robur* L.) trees were reported to have 45 percent greater height and twice the diameter of southern Michigan white oaks (*Q. alba* L.) of the same age (*8*). The apparent superior growth of the English oak may, however, be related to initial seedling size because English oak nursery stock tends to be larger than white oak stock (*3*), and seedling size has been shown to affect subsequent performance in several hardwood species. For example, trees grown from large stock of birch (*Betula pubescens* Ehrh. and *B. pendula* Roth), yellow poplar (*Liriodendron tulipifera* L.) and sweetgum (*Liquidambar styraciflua* L.) survived better and were taller than those grown from smaller stock (*2, 5, 1*). Similarly, large seedlings also produced taller trees of sycamore (*Platanus occidentalis* L.), northern red oak (*Q. rubra* L.), American elm (*Ulmus americana* L.), and green ash (*Fraxinus pennsylvanica* Marsh) (7, 4, 6). Therefore, the objective of this study was to compare the survival and growth of English oak and white oak seedlings of three size classes.

Methods

Acorns were sown in the fall of 1973 in the Union County Nursery near Jonesboro, III. The white oak acorns were collected locally, and the English oak acorns came from trees of unknown geographic origin planted on the Michigan State University campus at East Lansing, Mich. The seedlings were lifted in the fall of 1974 and kept in cold storage until the following spring. Seedlings of both species were sorted by stem caliper into lots of 100 each of three grades: Small (4/32 in), medium (6/32 in), and large (8/32 in).

In March 1975, the seedlings were planted on the Trail of Tears State Forest in Union County, III. The site is on Haymond silt loam and had been planted in corn the previous year; therefore, no ground preparation was done before planting. Six 33-tree rows were planted in each of three blocks at a spacing of 12 feet (3.66 m) between rows and 6 feet (1.83 m) within rows. Because this plantation was intended as a demonstration planting, one row of small English oak was followed by a row of small white oak; next came one row of medium English oak followed by a row of medium white oak; and then came one row each of the large grade. The same systematic arrangement was used in all three blocks. No herbicide was used the year of planting; but in the spring of 1976 and 1977, each row was strip-sprayed (1 .2 m wide) with Simazine herbicide at a rate of 5.6 kilograms of active ingredients per hectare.

Tree height and survival were recorded after seven growing seasons in the field (age 8 from seed). Analysis of variance and Duncan's multiple range test were used to test for differences between species and among size classes after arcsin transformation of survival percentages.

Results

Survival averaged 82 percent in both English oak and white oak. Although survival tended to improve with increasing seedling size in English oak, the differences among grades were small (table 1). Small white oak seedlings survived slightly better than medium seedlings, but the difference was not statistically significant (table 1). Because survival was about equal in the two species, the data were combined and analyzed for differences among grades. The result showed that large seedlings had significantly better survival than those of medium and small grades, which did not differ from each other.

1This study was carried out in cooperation with the Division of Forest Resources and Natural Heritage, Illinois Department of Conservation.

Table 1.—*Mean survival and height of English oak and white oak of three seedling grades after 8 years*

Species	Stock size	Survival1	Height[1]	C.V.[2]
		%	*M*	%
English oak	Large	88.0ab	2.58a	54
	Medium	85.7ab	2.25b	49
	Small	71.8c	1.810	31
White oak	Large	89.4a	2.13b	61
	Medium	75.8bc	1.68c	46
	Small	78.0abc	1.56c	40

[1] Means followed by a common letter do not differ significantly at P = 0.05.

[2] C.V. = coefficient of variation.

English oak averaged 2.24 meters in height at age 8 and was significantly taller than the white oak, which averaged 1.80 meters. Height was, however, related to seedling size in both species (fig. 1). In English oak, trees grown from the medium-grade and large-grade seedlings were, respectively, 24 percent and 42 percent taller than those grown from small seedlings. All differences among English oak grades were statistically significant (table 1). Medium-grade white oak trees were 8-percent taller than small-grade trees, but the difference was not significant. Large-grade white oaks were 36-percent taller than the small grade and significantly taller than those of the medium and small grades (table 1). When the data for the two species were combined, the differences in height among the three grades were all significant.

Although English oak, on the average, was taller than white oak, some white oak trees grew as well as or better than certain English oak trees. For example, large-grade white oaks were taller than small-grade English oaks and not significantly shorter than medium-grade English oaks (table 1). Individual trees of each species varied greatly in height (table 1) as was also found in a previous study (3). Much height variation was also observed within each seedling size class. The tallest individual white oak (3.9 m) was a large-grade tree; in comparison, the tallest English oak (5.2 m) was a medium-grade tree.

Discussion

This study shows that, although seedlings of English oak and white oak survived equally well, large-

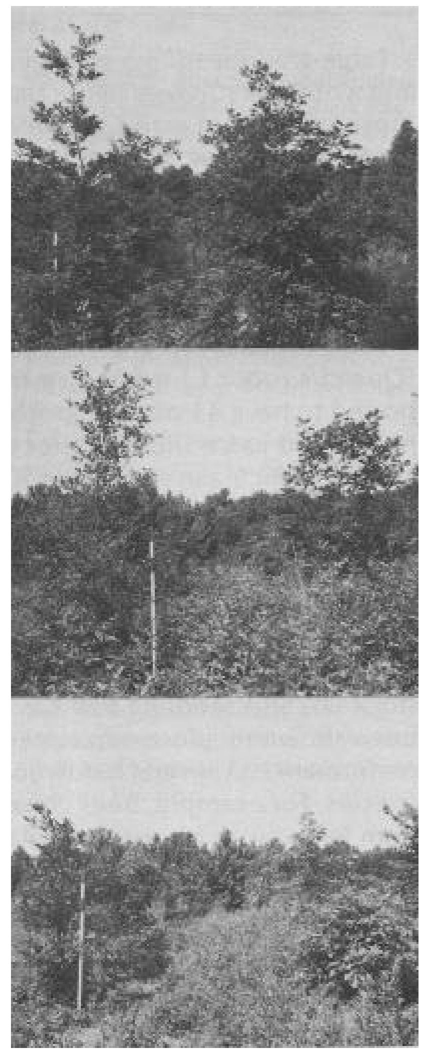

Figure 1.—*Eight-year-old English oak (left) and white oak (right) grown from seedlings of large grade (top), medium grade (center), and small grade (bottom). The pole is 5 feet (1.5m) tall.*

grade seedlings had better survival than those of medium and small grades. English oak, on the average, was 24 percent taller than white oak at age 8, which confirms previous reports of its superior early height growth. However, height was closely related to initial seedling size in both species, so substantial growth gains can potentially be obtained by using larger seedlings. Because of the large amount of height variation in white oak, it may be possible, through progeny testing and selection, to find some white oaks that grow as well or better than English oak.

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Twenty-Year Results of Planted Cherrybark Oak on Old Fields in Brown Loam Bluffs

Roger M. Krinard and John K. Francis
Mensurationist and Soil Scientist,
USDA Forest Service, Southern Forest
Experiment Station,
Stoneville, Miss.

Twenty years after planting, dominant/codominant cherrybark oaks averaged 55 to 65 feet tall.

Cherrybark oak (*Quercus flacata* var. *pagodifolia* Ell.) is a favored hardwood species in the deep loess soil areas of the brown loam bluffs either where erosion has not occurred or where at least 6 inches of topsoil remains; however, the species has not been listed as being suitable for planting (*3*). Five 19- or 20-year-old cherrybark oak plantings described here were successful. These were planted on old fields of Memphis and Loring soils in the loess hills northeast of Vicksburg, Miss.

Methods

Plantings ranged in size from less than an acre to almost 10 acres. From one to four plots per area were measured, with plot sizes of either 0.05, 0.07, or 0.10 acre. Diameters at breast height (d.b.h.) of all trees greater than or equal to 2.0 inches were tallied. Heights of five or six dominant or codominant planted oaks per plot were measured, as were heights of other species comparable to the tallest oaks. Soil pits were dug and descriptions made in each area.

Results and Discussion

Areas 1 to 4 were 1962 plantings-20 years old-while area 5 was planted in 1963 (table 1). Area 4 was in pasture at the time of planting while the other areas were old fields. The planting sites were disked before planting.

The soils on the plots are a Memphis-Loring complex. The principal soil variation is the presence (Loring) or absence (Memphis) of a fragipan and the intensity of its development. The fragipans, however, appeared to have had little effect on the growth of the planted cherrybark. Textures were mostly silt loam in the *A* horizons and silty clay loam in the *B* horizons. These loess soils are extremely erodible, and 50 to 100 years of agricultural use has caused the loss of about 8 inches of soil from their surfaces as estimated by the proximity of the fragipan to the surface. However, the topsoil, as represented by depth above the first 8 horizon, varied from 8 to 23 inches between areas. Value for pH varied from 4.0 to 4.6 in the upper 24 inches.

Oak survival could not be determined for the areas. The sites were machine planted, but not cross-marked in a square or rectangular pattern. Spot samples across the areas indicated variation between (from 8 to 12 feet) and within (from less than 7 to about 10 feet) row spacings. Apparent nominal spacings varied from approximately 7 by 8 feet (778 trees per acre, area 5) to 9 by 10 feet (484 trees per acre, area 1). By areas, number of oaks per acre after 19 to 20 years ranged from 155 to 565, with an average of 346 trees

Table 1.—*Average plot data for planted cherrybark oak at five locations after 19 (area 5) or 20 years*

		All trees			Dominant/codominant trees		
Area	Species	Trees/acre	D.b.h.	Basal area	Trees/acre	D.b.h.	Ht
			In	*Ft²/acre*		*In*	*Ft*
1	Oak	332	5.4	57	60	7.6	58
	Other	2	3.9	< 1	—[1]	—	—
2	Oak	155	7.8	54	60	9.5	65
	Other	90	5.4	16	5	8.0	64
3	Oak	565	5.1	88	83	7.4	55
	Other	—	—	—	—	—	—
4	Oak	375	5.4	67	100	7.4	63
	Other	285	4.5	40	20	7.2	62
5	Oak	400	4.5	50	100	6.2	55
	Other	340	3.8	32	30	6.7	55

[1]— = not applicable or not available.

per acre, based on all 13 plots.

Average oak d.b.h., by areas, ranged from 4.5 inches—where stocking was greatest—to 7.8 inches-where stocking was lowest; the larger dominant/codominant trees ranged from 6.2 to 9.5 inches d.b.h.

The largest individual oaks by areas varied from 8.6 inches d.b.h. and 59 feet tall to 13.9 inches d.b.h. and 76 feet tall. Average heights of the dominant/codominant oaks ranged from 55 to 65 feet. A sample of the dominant/codominant oaks over all areas averaged 16 feet maximum crown diameter, 51 percent live crown ratio, and 12 feet of clear bole length. In area 5, several of the planted oaks were southern red oak (*Quercus falcata* Michx.), rather than cherrybark oak, but on each plot a southern red oak was among the dominant/codominant component.

Other species in the dominant/codominant category were sweetgum *(Liquidambar styraciflua* L.), yellow-poplar *(Liriodendron tulipifera* L.), black cherry (*Prunus serotina* Ehrh.), and sassafras (*Sassafras albidum (Nutt*.) Nees). Other species measured on the plots were white ash *(Fraxinus americana* L.), boxelder (*Acer negundo* L.), blackgum (*Nyssa sylvatica* Marsh.), flowering dogwood (*Cornus florida* LJ, American elm (*Ulmus americana* L.), winged elm (*U. alata* Michx.), hickory (*Carya* spp.), red mulberry (*Morus rubra* L.), persimmon (*Diospyros virginiana L*.), red maple (*Acer rubrum* L.), and sumac *(Rhus spp.).*

The appearance of the cherrybark oak plantings is good. The trees have good form and are in a position to continue development and therefore be the major sawtimber component in the future. As there was no weed control in the year of establishment or thereafter, the oaks have developed without the aid of human beings. Intensive culture is required for eastern cottonwood (*Populus deltoides* Bartr. ex Marsh.) plantations; and disking for weed control has resulted in significantly greater heights, diameters, and survival for several different planted hardwoods compared to mowing or no weed control on both Sharkeyclaysoil (*4*) and Commerce silt loam soil (*5*) during the first 4 years of tree growth. However, the plantations in this study indicate good oak development is possible on old field loess soils without vegetative control following planting.

Potentially, these sites can probably produce 100-foot trees in 50 years. From site index curves for cherrybark oak, 55- and 65-foot trees at age 20 approximate 100- and 120-feet site indices at age 50; from soil series data, Memphis-Loring soils with at least 6 inches of A horizon' have an estimated site index range of 95 to 105 feet (*2*). However, an objective-subjective site evaluation method (*1*) only provided a site index determination of about 75 feet. Considering the present development of the trees, the latter method does not seem to be suitable for these sites.

Planting of cherrybark oaks on abandoned fields in the loess hills appears to be a reliable method for establishing a valuable oak component. Recommendations for plantation establishment would be to disk before planting and to use large, vigorous seedlings with at least 3/8-inch root collar diameters (*6*). Three hundred trees per acre at a 12- by 12-foot spacing would provide for a minimum of 100 sawtimber-size trees (14 in. d. b. h.) at 100 square feet of basal area if only one-third of the trees survived.

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Spot Sowing of Mediterranean Pines Under Shelter[1]

D. Heth[2]

Forestry Division, Agricultural Research Organization, Ilanot, Israel

Direct seeding under inverted plastic cups on raised, prepared spots was demonstrated to be a successful and cost-effective forestation method in Israel. Tests were conducted with three pine species on two common soil types. The procedures may be useful in Mediterranean climates elsewhere.

Direct seeding of conifers as a cheap forestation technique has long attracted foresters (*1, 2, 3, 10*). However, most forestation work is presently done by planting naked-rooted or balled stock. Planting is preferred to sowing because biotic factors and vegetative competition have less effect on seedling survival. It is, therefore, assumed to result in more uniform survival and growth. One of the rare exceptions in the Mediterranean basin is Cyprus, where direct seeding is the main forestation technique (8).

In the early 1970's, a new approach to direct seeding was developed in Finland (6, 7) and Sweden (*4, 9*). The new method consists of spot sowing under the shelter of plastic cups. Trials along this line have been carried out elsewhere (*5*).

Spot sowing success is strongly affected by climatic conditions. Thus, Mediterranean conditions require certain modifications of the original Scandinavian technique. In northern latitudes, growth occurs mainly during summer, but in the Mediterranean region much growth can occur during the mild winter and spring when water is most available. Therefore, while spot sowing under shelter is done in spring (May) in Finland (*7*), in Israel the suitable season is early winter (December to January). In Finland, the plastic cups are left in the field to disintegrate. This takes at least two growing seasons. In Israel removal of the cups is necessary after 2 to 4 months to avoid overheating and excess drying of seedlings during "sharav" conditions (hot easterly winds), which occur during March and April.

Materials and Methods

Experiments were carried out at four plots representing two types of Mediterranean climate-the accentuated thermomediterranean Galilee mountains and the xero-thermomediterranean Judean foothills (*11*)—and two soil types—terra rossa and rendzina (table 1 and fig. 1).

The soil was prepared by destroying the natural vegetation by burning or plowing, loosening the soil to a depth of 20 to 30 centimeters by plowing or by pick-axe and hoe, and applying herbicide (Simanex 50 W.P., Agan Ltd., Ashdod, Israel). At the time of sowing

Table 1.—*Site conditions of the experimental plots*

Site description	Galilee site		Judea site	
	Brown rendzina soil	Terra rossa soil	Pale rendzina soil	Terra rossa soil
Longitude E.	35°26'	35°27'	34°59'	35°02'
Latitude N.	33°03'	33°04'	31°49'	31°49'
Elevation (m)	725	675	260	475
Exposure	Level	South	South	Level
Rainfall (mm)				
Mean annual	646	702	479	582
1980-81	994	934	491	591
1981-82	—[1]	560	465	545
Daily temperature (°C)				
Mean maximum				
Warmest month	27.7		32.4	
Mean minimum				
Coldest month	4.5		7.7	

[1]– =data not available or not applicable.

[1]Contribution from the Agricultural Research Organization, Bet Dagan, Israel. No. 662-E, 1983 series.

[2]This research work was supported by funds received from the Jewish National Fund Forest Service. Their support is gratefully acknowledged.

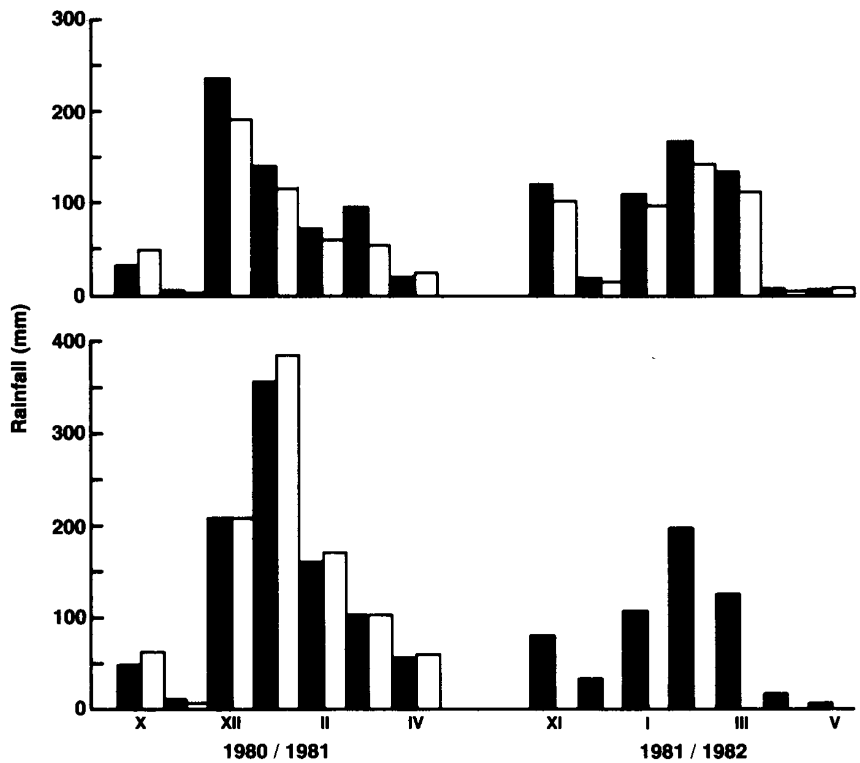

Figure 1.—*Monthly rainfall amounts (mm) in experimental plots in 1980-81 and 1981-82. Top—Judean foothills (black = terra rossa, Bet Me'ir; white = pale rendzina, Har'el); bottom —Gaililee (black = terra rossa, Yir'on; white = brown rendzina, Bar'am). Data from Bar'am for 1981-82 are not available. (Roman numerals denote month.)*

the upper 2 to 3 centimeters of soil were removed to avoid herbicide damage to germinating seedlings.

Sowing was done in the Judean foothills from the end of December1980 to the beginning of January 1981 and in Galilee at the beginning of February 1981. Three to four weeks before sowing, seeds of three species of pine were soaked in waterfor24 hours; floating seeds were removed and the rest were placed in moist vermiculite for germination. At the time of emergence of the rootlet, the seeds were sown in the field at a depth of 2 to 3 centimeters on so-called "molehills" (fig. 2A), according to current practice. On each molehill (spot), three *Pinus pinea* L. seeds or five *P. brutia* Ten. or *P. Halepensis Mill*. seeds were sown, covered with soil, and sheltered by a plastic cup (current price: $14 per 1,000).

The transparent cup (light transmission 85 to 90 percent) is pierced at its base to form a 1.0- to 1.5-centimeter-wide hole (fig. 2B). The inverted cup is pushed into the soil to a depth of 1.0 to 1.5 centimeters, with its 2-millimeter rim strengthening its hold on the soil. If the surface soil is dry, the seed spot is watered by spraying for a few seconds. Ecogan Gammacide 7 dust (Makhteshim Ltd., Be'er Sheva, Israel) was applied to prevent damage by seed-collecting ants. In each plot, sowing was replicated 5 to 10 times with a total of 100 to 189 sown spots per species. Two to three months after sowing, in the spring, but before the occurrence of "sharav" conditions, the plastic cups were carefully removed and the seedlings thinned to two or three per spot. During the first and second springs, soil around the seedlings was hoed. Seedlings will be thinned to one per spot 2 to 4 years after sowing, depending upon growth rate.

Results

Results of the trials are summarized in figures 3 and 4. Survival of the seedlings in the four plots was quite high (70 to 90 percent). Differences in growth of *P. halepensis* (Aleppo pine-ed.) between the two soil types were pronounced, but not so in *P. brutia* (Calabrian pine-ed.). Survival of *P. pinea* (Italian stone pine-ed.) on pale rendzina was lower than in other plots; this was apparently

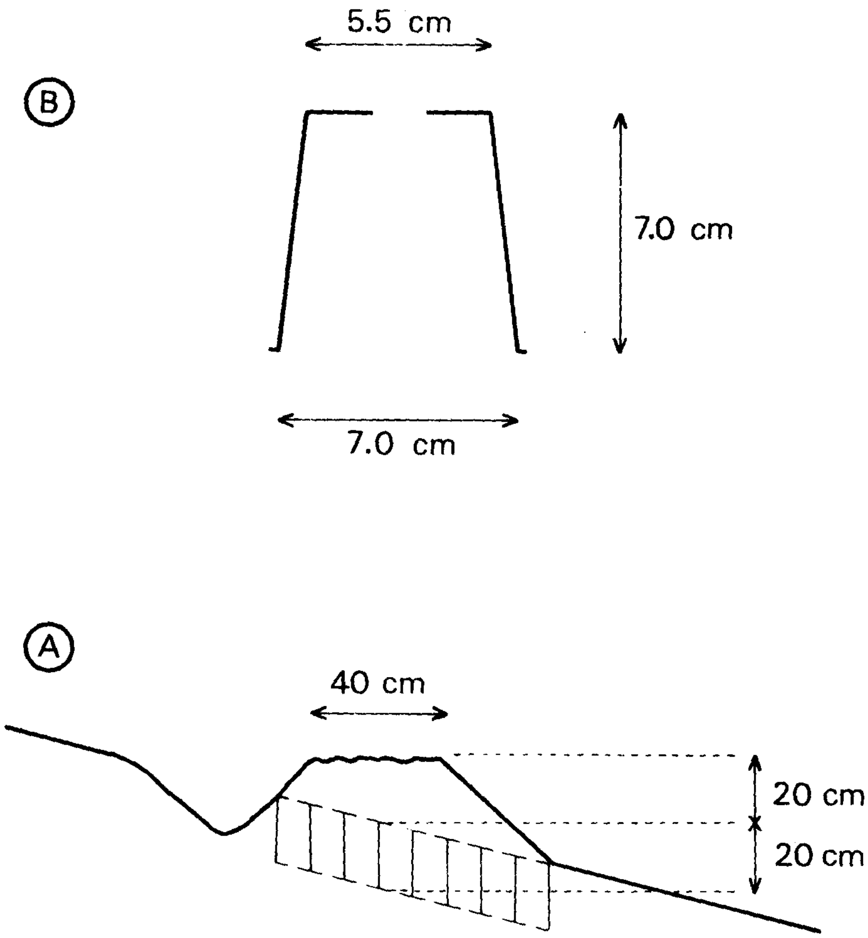

Figure 2.—*Cross sections of (A) seedling spot ("molehill") and (B) plastic shelter (cup). Loosened soil beneath the artificially raised "molehill" is indicated by vertical bars.*

because some of the cups were not placed exactly on the seed spots, thereby reducing the survival rate during the first winter.

Discussion and Conclusions

The current method of forestation in hilly areas of Israel-hand-planting of naked-rooted, 13- to 15-month-old nursery stock—is an efficient and proven technique. However, it is quite expensive, and seedlings grown in containers (tins) are sometimes crooked at the root collar or have an inadequate top-root ratio. Still, forestation involving large amounts of manual labor may soon come to a standstill because workers are becoming scarce and more expensive. Thus, there is a need to mechanize forestry operations. Current expenses for forestation (during the first 2 years) in hilly areas are about $2,090 per hectare; personnel costs account for two-thirds and materials (mainly seedlings at 2,500 per hectare) for one-third of the expenses. Comparison with Cyprus (*8*) shows that forestation there is much less expensive (planting-$900/ha and direct seeding-$450/ha). Two-thirds of the area forested annually is seeded and one-third is planted.

In conclusion, in hills in the Mediterranean region with a mean annual rainfall of more than 400 millimeters (figs. 3 and 4), under-shelter spot sowing of pine provides 70- to 90-percent survival rates. This technique is suitable for the main forest soils in Israel—terra rossa and rendzina. The technique has both advantages and disadvantages in comparison with the current method of planting naked-rooted stock, but the advantages markedly exceed the disadvantages. Advantages are: (*1*) Raising the nursery stock for 13 to 15 months is dispensed with; (*2*) The "shock" caused by the transfer of the seedlings from the nursery to the field and distortion of the root system is avoided; (*3*) The roots of spot-sown seedlings are better developed than those of planted stock (*5*); (*4*) There is no need to plan forestation 1 ½ years ahead, as only a few weeks are required; (*5*) Since several seedlings

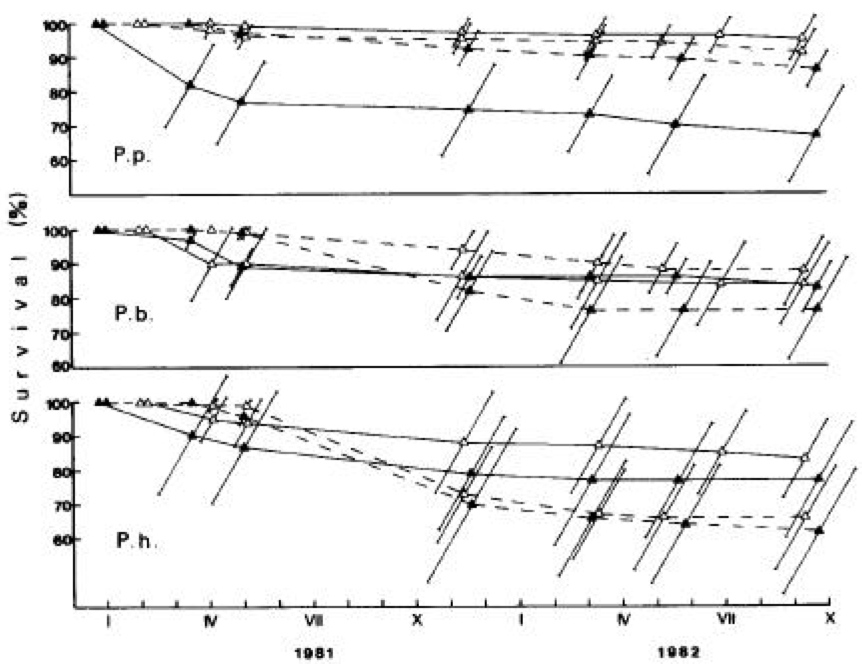

Figure 3.—*Survival (%) of seedlings from direct seeding. P.b. = P. halepensis; P.p. = P. pinea. ? = Judean foothills; ? = Galilee; broken line = terra rossa; solid line = rendzina.*

will germinate in each spot, competition during the first years will hasten their height growth and improve their form (thus, after 2 years, the height of *P. halepensis* from spot sowing nearly equaled that of nursery-raised stock when sowing and planting in the field were done at the same time); (*6*) Direct seeding is more suitable for mechanization than planting; (7) The use of a sowing dibble developed in Finland (Tyevaline Oy, Espoo) dispenses with the need for the worker to stoop down during seeding; and (*8*) Spot sowing under shelter will save about 50 percent of the costs of the current forestation technique.

On the other hand, seedlings in the first 2 years are most often smaller than planted stock; thus, they may need additional protection and cultivation, as well as increased supervision of personnel at all stages of the work.

This application of spot sowing under shelter seems to be suitable for pine forestation under Mediterranean climates in Israel as well as in California, while the original Scandinavian technique applies to cooler climates.

Summary

Field trials were carried out to compare growth and survival of three species of pines in reforestation of Mediterranean hilly areas by an improved technique of direct seeding. The use of spot sowing under plastic shelter is recommended as a reliable forestation technique. The technique could be suitable for forestation of similar areas in the United States.

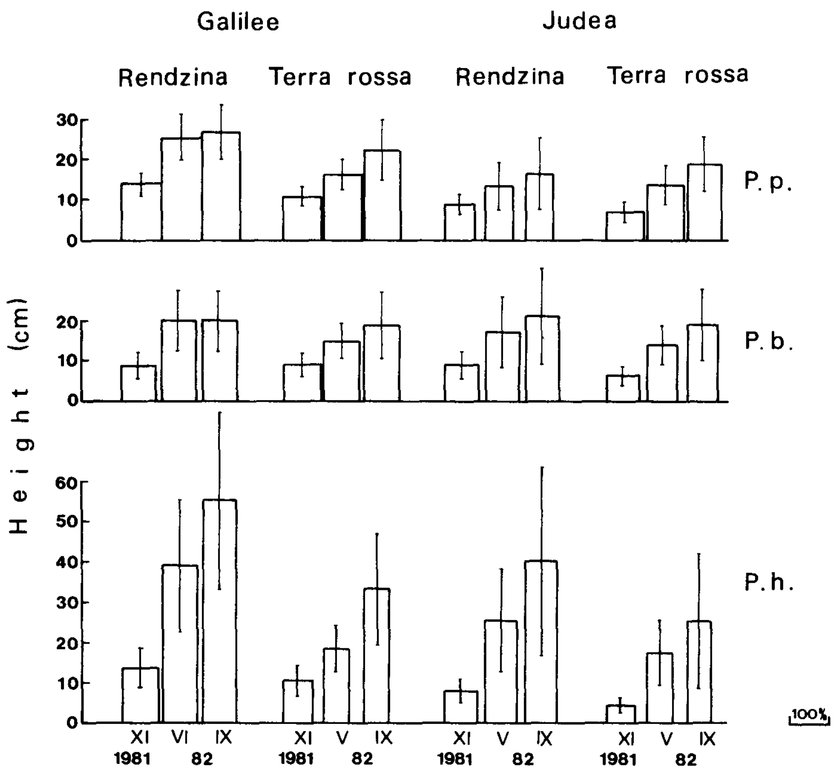

Figure 4.—*Height (cm) of seedlings from direct seeding on three dates in 1981 and 1982 P.b. = Pinus brutia; P.h. = P. halepensis; P.p. = P. pinea. Bar width indicates average survival percentage in the treatment at measurement time. The scale to the right indicates 100-percent survival.*

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Tree Planter's Notes, Vol. 34, No. 4 (1983)

A Simple Method for Temporary Cone Storage

Daniel R. Anderson
Reforestation Forester, Soper-Wheeler Co., Strawberry Valley, Calif.

A simple method for field storage of bagged cones using pallets and 2 by 4's is described.

A simple means of temporarily storing green cones that allows for adequate air circulation to prevent the build up of harmful temperatures or molds has been successfully used for the past 2 years. Cones of ponderosa pine, Douglas-fir, white fir, red fir, incense cedar, Jeffery pine, and sugar pine were stored on the racks with no adverse effects.

The storage racks are made up of pallets and 2 by 4's. The pallets were made from 2 by 4's and 1 by 4's and are easliy adapted for other uses such as holding Leach single-cell container systems for growing seedlings.

The cone racks are made by standing the pallets on end with 2 by 4's placed between them to hold the sacks of cones. The pallets used here were 4 by 4 feet with five l by 4's on the side that would normally be up and three on the bottom (fig. 1). By extending the 2 by 4's used to hold the sacks through the pallet, five tiers of sacks on each half of the pallet could be made (fig. 2). Fifty 100-pound potato sacks, each containing a maximum of 1 bushel of cones and tied at the top to allow room for cone expansion, could be placed on 8-foot 2 by 4's between two pallets (fig. 3). With

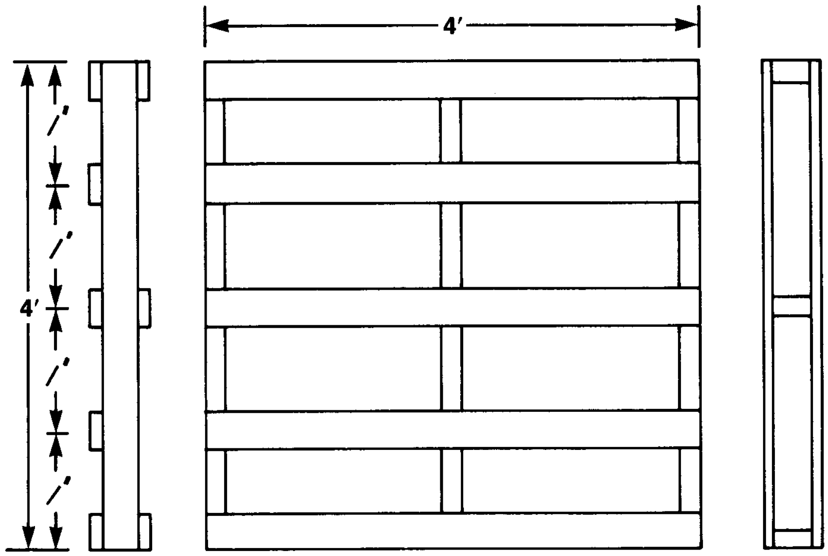

Figure 1.—*Side, front, and top view of pallet constructed with 2 by 4's and 1 by 4's.*

only 1 bushel of cones per sack, there is room for the cones to spread out when the sacks are laid flat on the racks, allowing for adequate air circulation between cones and sacks and good use of available space. Even the bottom tier of sacks has 4 inches of clearance under it for air circulation.

Reasonably good lumber should be used because the weight of the green cones is substantial. Eight-foot 2 by 4's were generally used between pallets, because 10-foot lengths resulted in considerably more sag in the middle than the "8-footers" did.

This system works well wherever there is reasonably flat ground to stand the pallets on, although some slope can be tolerated by tying a pallet or two to something solid (e.g., a tree in the field or a post on a fence) to prevent side-shifting of racks of cones. One advantage of this system is that the number of racks can be extended indefinitely by simply adding a new pallet to the end of the string and adding the 2 by 4's necessary to make a new rack. Also, possibilities for arranging the racks are almost unlimited since the distance in any one direction can be as short as 8 feet.

Another advantage to this system is that you can easily add sacks of cones to the racks because the next level of 2 by 4's need not be added until the lower level is filled. Thus, you can always lay sacks down from the top and never have

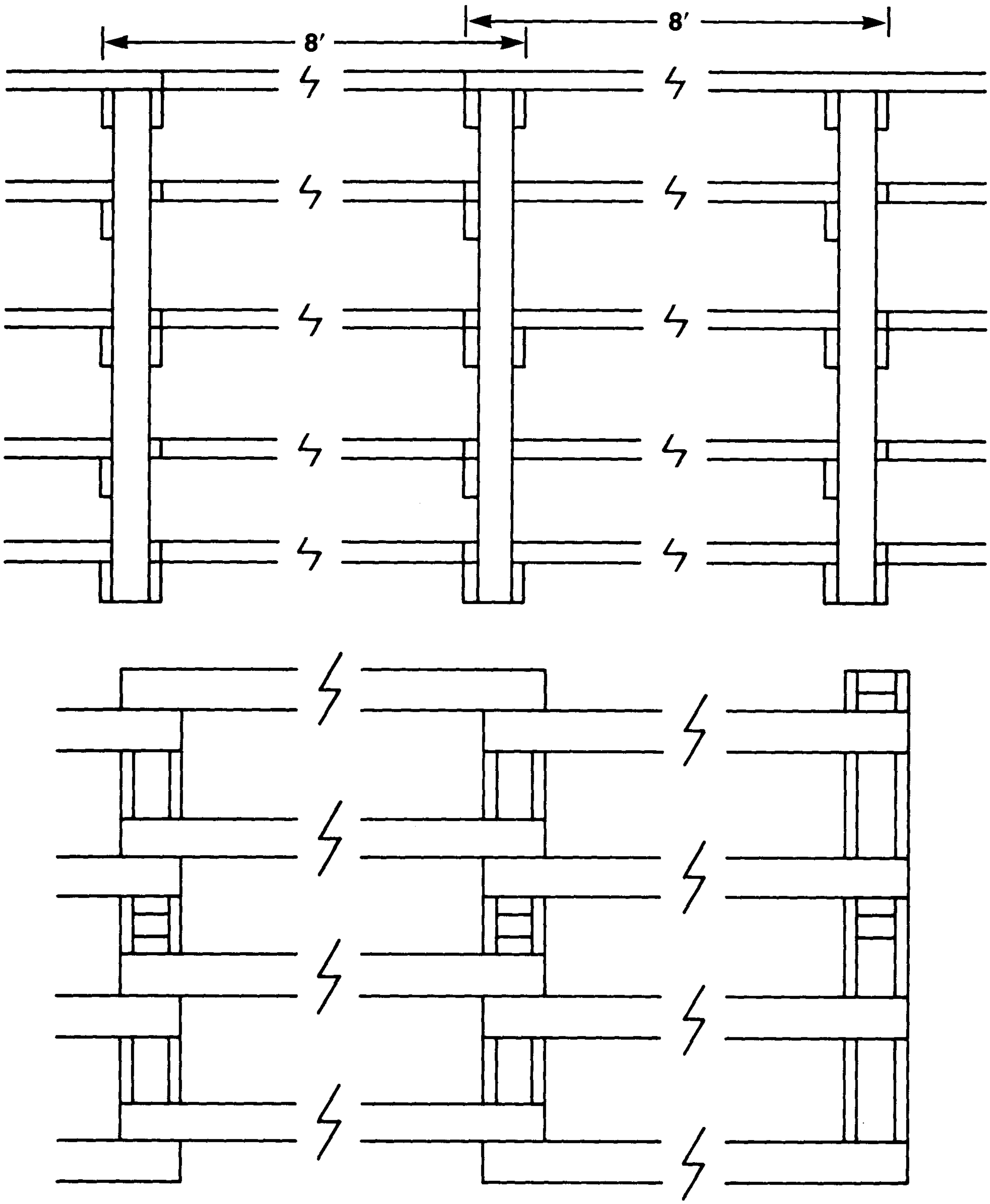

Figure 2.—*Side view (top illustration) and top view (bottom illustration) of pallet and 2-by-4 arrangement. Five sacks of cones can easily be placed between two pallets on each level on each side for a total of 50 sacks between two pallets.*

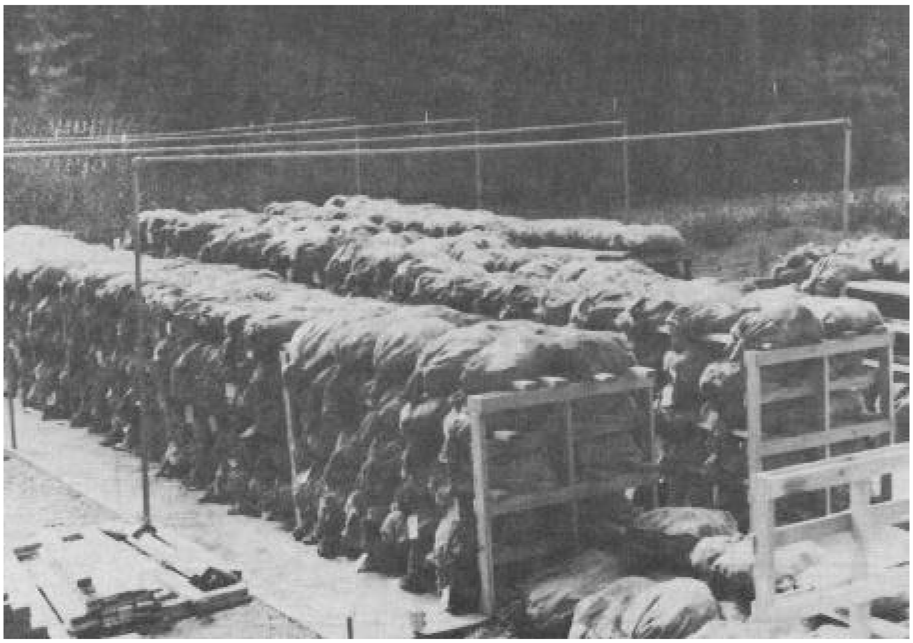

Figure 3.—*View of sacks of cones stored on pallet and 2-by-4 racks. Note that some racks are only partially filled.*

to slide sacks in between rows of 2 by4's. One person can easily build or tear down racks of cones if necessary.

The tagged ends of the sacks should be placed toward the outside for easy reading. Also, a small spot of spray paint applied to the end of the sacks, using a different color for each different lot of cones, makes locating a particular lot easy. This way, sacks of one lot can be easily removed even if various lots are mixed on the racks.

When finished, both the pallets and 2 by 4's can be stored in a relatively small area until needed again. Also, transportation to field locations is easy since a pickup truck can haul enough pallets and 2 by 4's to store 200 to 300 bushels of cones.

Tree Planter's Notes, Vol. 34, No. 4 (1983)

First-Year Survival of Morphologically Graded Loblolly Pine Seedlings in Central Louisiana

Charles R. Venator
Research Plant Physiologist, USDA Forest Service, Southern Forest Experiment Station, Pineville, La.

Morphological grades have definite correlations with loblolly pine seedling survival potentials. Such grades are especially important when droughts occur in the first growing season. At such times intermediate-sized seedlings survive drought stress better than larger or smaller seedlings.

For more than 50 years, nursery personnel have recognized that grading southern pine seedlings can improve regeneration success. Seedlings generally are graded for such morphological characteristics as height, root collar diameter, presence of secondary needles, needle length, woodiness of stem, presence of bark on the stem, and terminal bud condition. A description of morphological grades for uninjured 1-year-old southern pine seedlings is given by Wakeley (*7*), and these grade classes are widely used throughout the South.

In the past decade, many nursery workers have stopped grading seedlings to reduce operating expenses. This practice is questionable because, during the same period, several reports have indicated that grades 1 and 2 loblolly and slash pine seedlings outgrew grade 3 when fieldplanted (*8, 3, 4*). In Queensland, Australia, Bacon and others (*1*) distinguished eight morphological grades of slash pine seedlings. Six of these eight grades had statistically better survival and growth rates than the two inferior seedling grades. Although there is little disagreement that larger seedlings grow faster than smaller seedlings, there is varying evidence that larger seedlings survive better than smaller seedlings, as was pointed out by Wakeley (8). In a review paper, Sutton (6) discussed the relative merits of planting-stock quality and grading and how this affected seedling survival. He emphasized that morphological grade alone is not a reliable indicator of the capacity of seedlings to survive. He reviewed the impact of several physiological conditions such as mineral nutrition status, hormonal levels, and cold hardiness, but no conclusions were made. He concluded that much work remains to describe the physiological characteristics of high-quality seedlings and the impact of such characteristics on seedling survival.

The survival of morphologically graded loblolly pine seedlings is discussed in this report. These data were collected from a study designed to test the effect of seedling grade on survival and long-term growth. Shortly after planting, a severe, prolonged drought struck central Louisiana. Consequently, data reported here reflect the ability of the various grades to survive drought conditions.

Materials and Methods

In January 1980, seedlings that conformed to three different grade classes were selected from tubs at the Forest Service W. W. Ashe Nursery in Mississippi. Root collar diameters were greater than 7/32 inch for grade 1 seedlings, from 4/32 to 6/32 inch for grade 2 seedlings, and from 2/32 to 3/32 inch for grade 3 seedlings. The seedlings used in this study were grown at a seedbed density of about 27 per square foot. Except for the slightly larger root collar diameters, all other morphological characteristics described by Wakeley (*7*) were followed.

After grading, the seedlings were packed in polyethylene-lined kraft paper bags and stored at 34° F for 30 days. Theywere planted in February 1980 in six random blocks. Each block had 121 seedling plots of grade 1, grade 3, a mix of grades 1 and 2, and a balanced mix of all three grades planted at an 8- by 8-foot spacing.

In an effort to achieve adequate stocking for the long-term volume production part of this study, two seedlings were planted 6 inches apart. Because of the statistical design selected (to measure competition between plots and within plots having mixed seedling grades), there were 1,861 grade 1, 1,686 grade 2, and 2,712 grade 3 seedlings planted. The seedlings were handplanted on a sandy loam site that had been bushhogged and burned the previous fall. Survival was determined in late October 1980.

Table 1.—*Percentage of surviving seedlings separated into morphological grades 1, 2, and 3*[1]

Morphological class	Alive	Total planted	Percentage alive
Grade 1	934	1,861	50.2 ± 24.86b[2]
Grade 2	1,111	1,686	65.9 ± 14.49a
Grade 3	1,459	2,712	53.8± 11.93b

[1] Seedlings were outplanted in February 1980, and survival was measured in October 1980.
[2] Data sets followed by different letters are statistically different at the P - 0.05 level.

Results and Discussion

A count showed that only 50.2 percent of the grade 1 seedlings survived, while 65.9 percent of the grade 2 seedlings survived (table 1). Intermediate in survival to these two grades were the grade 3 seedlings, of which 53.8 percent survived.

Seedling survival apparently was influenced to a large extent by the severe drought that began in early spring of 1980 and extended to midsummer. The drought undoubtedly reduced seedling survival in this specific study since some nearby 3-year-old plantations were so severely affected that they had to be replanted. Table 2 illustrates the severity of the 1980 drought. For May through August, total rainfall was 3.02 inches versus a 16-year average of 18.24 inches. Total rainfall for May through September was 4.99 inches versus an average of 22.05 inches. Thus, total rainfall for the 4-month period was 16.6 percent of the expected amount and for they-month period only 22.6 percent of normal. For 1980, rainfall was only 65 percent of the 16-year rainfall average. As a result of this low survival, the long-term objective of this study was cancelled since adequate and uniform stocking was not obtained for any of the three grades.

Table 2.—*Rainfall data for the J. K. Johnson Tract of the Palustris Experimental Station in central Louisiana*

	Average monthly rainfall	
Month	1952-1978	1980
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January	5.20	6.13
February	4.55	3.85
March	4.90	6.76
April	5.74	5.54
May	5.35	.12
June	3.68	.51
July	5.09	1.51
August	4.12	.88
September	3.81	1.97
October	3.18	4.50
November	5.01	3.78
December	7.12	1.80
Total	57.75	37.35

The Student-Newman-Keuls multiple comparison of means test showed that the mean survival of the grade 2 seedlings was statistically different than grades 1 and 3 at the 5-percent level of probability (table 2). However, because of the drought, none of the three morphological classes of loblolly seedlings had a survival rate close to the 450 trees per acre that is accepted as normal for operational success.

This study indicates that grade 2 seedlings do have a survival potential edge over the other grades and will survive better in a severe droughty period during the first growing season. Bengtson (2) reported similar results from a 1954 study with slash pine where he compared "super" nursery seedlings with average-sized seedlings. The select seedlings grew faster over an 8-year period, but had about 50-percent greater mortality than the average-size seedlings. He also reported that the first growing season was extremely dry and concluded that this had a negative impact on the ability of larger slash pine seedlings to survive.

Bacon (*1*) also studied slash pine morphological differences and their effects on seedling survival. He concluded that taller seedlings had higher outplanting mortality. Higher survival was better correlated to larger root collar diameter and to a dormant bud at the time of planting.

Sluder (5) analyzed the interaction between seed size and seedling size on height and survival of loblolly pine. He determined that seed size had no effect on survival at age 3, but seedling size did. The study showed that, at the 10-percent level of statistical significance, select seedlings survived better than average-size seedlings. He did not, however, define the seedling morphological parameters other than "average" and "select."

Given the frequent occurrence of drought in the South, it may be important to put more emphasis on the grading process. Over the past 15 years, seedling grading has been largely disregarded by most nursery managers. The results of this study indicate that the benefits of grading may only be recognized during times of stress. This may indicate that a generalized balance between top and root system does exist and is manifest during stress.

Existing evidence points toward increased long-term growth and yield of grade 1 seedlings over other grades. However, the results of this study indicate that it may be necessary to modify this by planting grade 1 only in wet sites or at a closer spacing since these appear to be more sensitive to drought than grade 2 seedlings.

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Height Growth of Noble Fir 8 Years After Planting in the Olympic Mountains

Marshall D. Murray and Dorothy LaRance
Forestry Consultant, Centralia, Wash. and Forest Technician, Quinault District, Olympic National Forest, Wash.

Eight years after they were planted in the Olympic Mountains, average height of noble fir trees was 7.9 feet. Annual height growth the previous 3 years ranged from 1.0 to 2.6 feet.

Snow damage to planted Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) has been observed at higher elevations in the Olympic Mountains on the Quinault District of the Olympic National Forest. Douglas-fir tops are damaged by snow; and boles are deformed by heavy snowpacks, which creep downslope during the winter. Douglas-fir has been the favored species for planting, although Pacific silver fir (*Abies amabilis* (Dougl.) Forbes) and noble fir (*A. procera* Rehd.) are more resistant to snow damage (*4*). However, noble fir is not native to the Olympic Mountains; the nearest natural stands are about 70 miles south in the Willapa Hills (*1*). Nothing is known of the productivity of this species on the Quinault District.

Within its natural range in western Washington, the relative productivity of young noble fir, as measured by the height of dominant trees, is less than Douglas-fir on high-quality Douglas-fir sites at elevations less than 2,700 feet, but is equal to Douglas-fir on low-quality Douglas-fir sites at elevations greater than 2,700 feet (*3*). Both noble fir and Pacific silver fir have slow early height growth; but past the juvenile phase, these true firs have a long period of rapid, uniform height growth and catch up with or surpass associated Douglas-fir and western hemlock (Tsuga heterophylla (Raf.) Sarg.) (*2*).

In 1974, some noble fir was planted on the Quinault District to test the growth and performance of this species. One trial planting was made on an east aspect at 2,700 feet elevation on an area with moderately deep, rocky soil. After the original stand of Pacific silver fir and western hemlock was clearcut in 1970, the area was broadcast burned and handplanted with Douglas-firin 1971. Initial survival was low; and the area was replanted in November 1974 with Douglas-fir, Pacific silver fir, and a small amount of 3+0 noble fir. Seeds for this noble fir came from a 3,000- to 3,500-foot elevation zone on the Snoqualmie National Forest in the Washington Cascade Mountains.

The early survival of planted noble fir is not known. The area now contains a small amount of scattered noble fir. The area also contains Douglas-fir from the two plantings in 1971 and 1974, Pacific silver fir from both planting and natural regeneration, and western hemlock from natural regeneration.

This paper reports on the total height and previous 3-year annual height growth of surviving noble fir 8 years after planting.

Methods

Thirteen noble fir trees of various diameters at breast height (d.b.h.) were selected for measurement. Diameter at breast height, total height, and annual height growth for the previous 3 years were measured. Two selected trees were in the 0.5-inch d.b.h. class, five were in the 1.0-inch d.b.h. class and six were in the 1.5-inch d.b.h. class.

Results and Discussion

Eight years after planting, the noble fir look healthy and vigorous. Measured total height ranged from 5.2 feet to 10.5 feet; measured annual height growth for the previous 3 years ranged from 1 .0 feet to 2.6 feet. Average values for total height and previous 3-year annual height growth, by diameter class, are shown in table 1.

Before widespread planting of noble fir at higher elevations is initiated, a long-term test of the relative productivity of this species on the Quinault District needs to be made. This small test has shown, however, that planted noble fir will grow in the Olympic Mountains.

Table 1.-*Average total height and average annual height growth by diameter class for noble fir 8 years after planting in the Olympic Mountains*

Diameter-at-breast height class	Total height	Previous annual height growth		
		1980	1981	1982
In	*Ft*		%	
0.5	5.8	1.0	1.5	1.2
1.0	8.0	1.4	1.6	2.0
1.5	9.8	1.7	2.3	2.4
Average	7.9	1.4	1.8	1.9

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Propagation of Juvenile Scots Pine Cuttings Under a 24-Hour Photoperiod

B. J. Phillion, J. deWitt, and W. R. Bunting

Vegetative Propagation Specialist, Nursery Propagationist, and Superintendent, Ontario Ministry of Natural Resources, Provincial Forest Station, Orono, Ontario

Successful rooting of juvenile Scots pine cuttings was achieved with continuous lighting. Under a 24-hour photoperiod, 83 percent of all cuttings had rooted in 8 weeks with minimal Botrytis losses.

Vegetative propagation of Scots pine (*Pinus sylvestris* L.) by cuttings is possible for juvenile (*2*), 5-year-old (*3*), and 10-year-old (*1*) plants. According to these references, the biggest problem in rooting Scots pine is fungal attack by Botrytis spp. To prevent Botrytis infection, relatively dry conditions are required; however, Scots pine cuttings need a lot of water during the propagation process.

Since Scots pine is a relatively light-intolerant species, we decided to try adding light to the cuttings during the propagation period. The additional light would increase the transpiration and photosynthetic rate. We hoped that this would reduce excess moisture around the cuttings, thereby decreasing the potential for Botrytis infection, and reduce the callusing and rooting time.

The objective of this article is to report on rooting success obtained with Scots pine cuttings rooted under supplemental lighting.

Scots pine cuttings were successfully rooted under a 24-hour photoperiod light regime with minimal losses to Botrytis spp. As light intensity increased, the cuttings rooted faster and produced greater root mass.

Methods

Scots pine seedlings were grown for 15 weeks (October 19, 1981, to February 1,1982) in Leach Super Cell[1] containers in a greenhouse under a 24-hour photoperiod of 5,000 to 6,000 lux supplied by high-pressure sodium lamps. On February 1, seedlings averaged 14.5 centimeters in height and 3.5 millimeters in diameter. At this time, the plants had ceased height growth and had set bud (presumably because the container restricted further growth). Cuttings were excised from the top 5 centimeters of the leader and planted in a 1:1 mixture of peat and vermiculite. Before planting, cuttings were treated as follows:

1. Control, no treatment.
2. Five-second dip in 4,000 parts per million indolebutyric acid (IBA). The source of IBA was STIM-ROOT.[2]
3. Wounding + IBA. Wounding consisted of 3 or 4 vertical cuts with a razor blade, each about 0.5 centimeter in length on the basal stem extending from the outer bark to the outer xylem.
4. Wounding.
5. Untreated cuttings planted in the same peat and vermiculite mixture except one-sixth of the vermiculite was inoculated with MycoRhiz[3] (*Pisolithus tinctorius*), a mycorrhizal fungus inoculum.
6. Wounding + IBA + MycoRhiz-inoculated medium as in treatment 5.

There were eight cuttings per treatment and two replications under each of three light conditions (288 cuttings total). The three light conditions were maintained for 24 hours per day and were as follows:

1. A minimum 5,000- to 6,000 lux light intensity. On cloudy days and at night, this was achieved with high-pressure sodium lamps.
2. In a bright portion of the greenhouse with natural sunlight during the day and a minimum 500- to 600-lux light intensity at night maintained with fluorescent lamps.
3. In a less illuminated portion of the greenhouse with approximately 60 percent of the daytime light intensity of 2 and a minimum 500 to 600 lux at night maintained by fluorescent lamps.

[1]Registered trade name of Ray Leach Cone-Tainer Nursery.

[2]Registered trade name of Plant Products Co., Ltd.

[3]Registered trade name of Abbott Laboratories.

Cuttings were planted in Leach Fir Cell[4] containers and placed under plastic supported by a light wooden frame (fig. 1). In general, the cuttings were not shaded. There were a few very bright, sunny days when the temperature under the plastic was excessive. On those occasions, shade cloth was placed over the cuttings of light treatments 1 and 2 for 4 to 5 hours during the day. Cuttings were misted with a fog nozzle and hose as required (at least once per day), and fungicides were applied twice per week. After 8 weeks, the cuttings were excavated and examined for roots. Root mass was not quantified at sampling time.

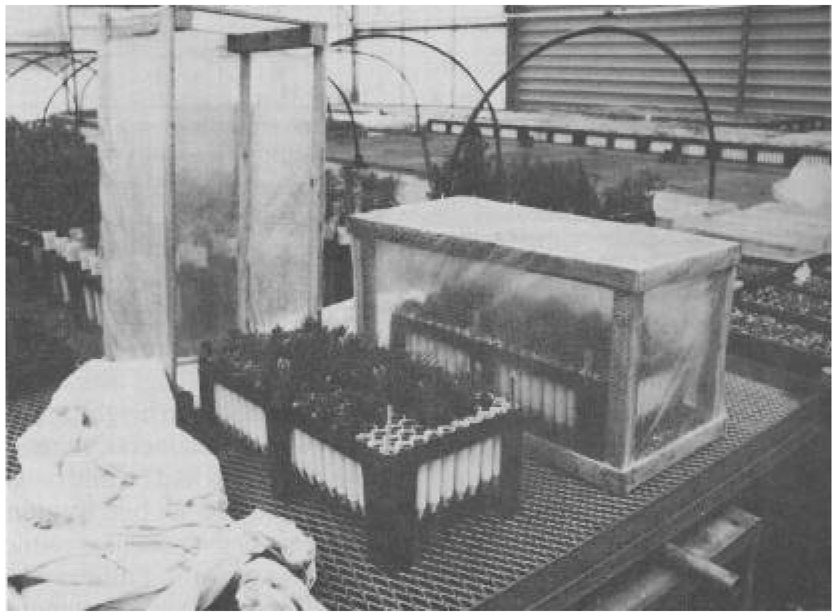

Figure 1.—*Plastic and supporting frame under which Scots pine was rooted.*

Results and Discussion

Most of the cuttings under a minimum 5,000- to 6,000-lux light intensity had callused 2 weeks after they were planted, and the first roots were noticed in the third week. Under light conditions 2 and 3, it took 3 and 4 weeks, respectively, to develop callus tissue, and rooting occurred in the following weeks. Cuttings produced roots in all treatments. After 8 weeks, 83 percent of all cuttings had rooted. Callusing and rooting occurred most rapidly under the highest light intensity treatment; and after 8 weeks, these cuttings had accumulated the greatest root mass (figs. 2 and 3).

All preplanting cutting treatments were successful in inducing root formation (table 1). Treatment differences within and between each light condition were statistically nonsignificant. An average of two to three roots were produced at the base of all rooted cuttings. Untreated cuttings (control) also produced roots, but on fewer cuttings (65 percent on the average), and their root mass was small compared to other treatments. Cuttings treated with IBA, wounding, and wounding + IBA had produced slightly heavier root systems after 8 weeks. Under all light conditions, cuttings with the greatest root mass were those planted in peat and vermiculite inoculated with MycoRhiz. It appeared that the MycoRhiz did not promote faster root production on cuttings, nor did it increase the number of roots at the base of the cuttings. Rather, MycoRhiz increased the branchiness and growth of the roots once they were initiated.

Cuttings rooted under light conditions 1 and 2 did not appear to be infected by *Botrytis* spp. Cuttings that did not root under light conditions 1 and 2 suffered from drought and many of them had desiccated before the end of the 8-week propagation period. These cuttings were located at the edge of the tray where the rooting media dried faster than in the

[4]Registered trade name of Ray Leach Cone-Tainer Nursery.

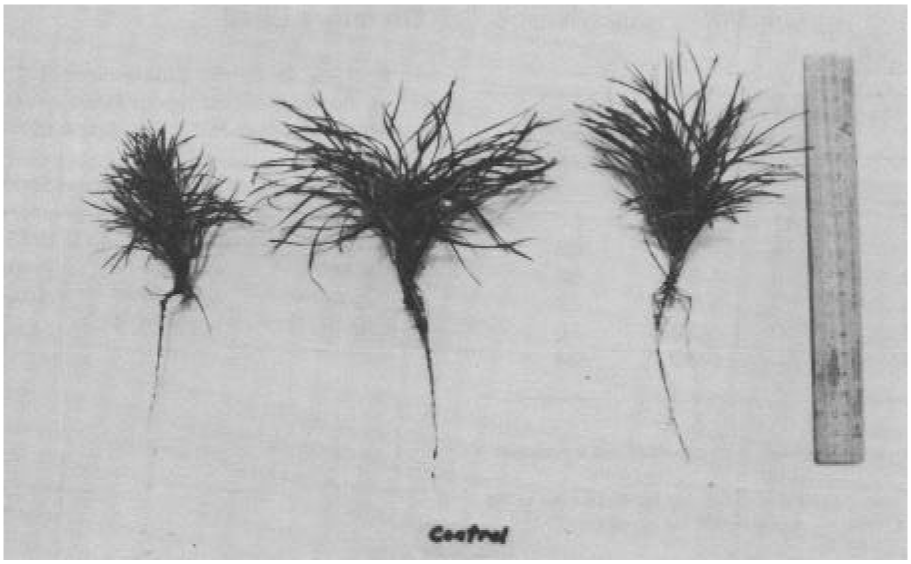

Figure 2.—*Typical untreated (control treatment) Scots pine cuttings from light condition 1 (right), light condition 2 (center), and light condition 3 (left).*

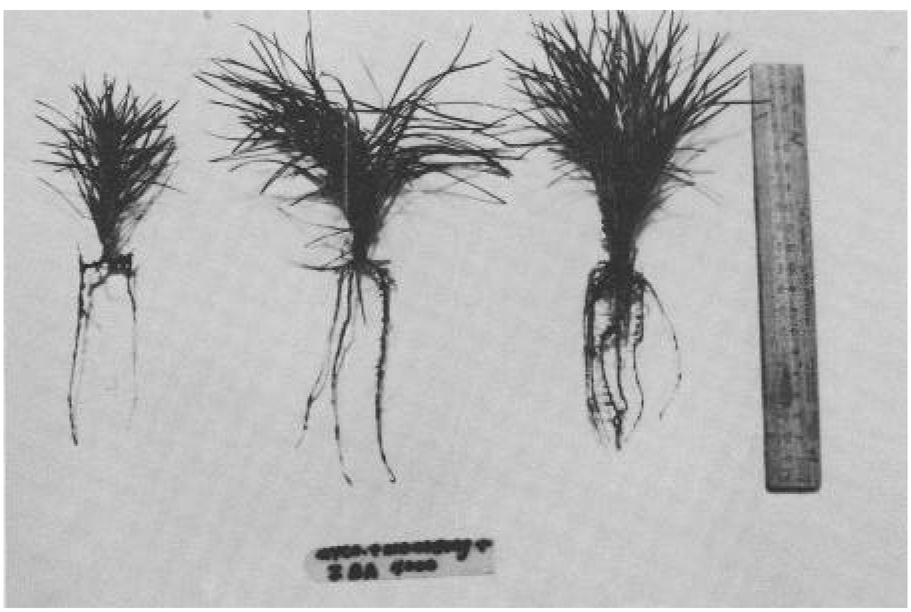

Figure 3.—*Typical cuttings treated with wounding + I8A + planted in MycoRhiz-inoculated medium from light condition 1 (right), light condition 2 (center), and light condition 3 (left).*

center of the tray. Because each tray stood separately in its rooting environment, we presume that a greater proportion of the cuttings would root when more trays were added on a production scale. Under light condition 3, many of the cuttings that did not root had been infected by *Botrytis* when sampled after 8 weeks; it appeared that none were lost to drought.

Conclusion

The experiment did not measure actual light intensity because it is very difficult to quantify in a greenhouse environment. Nevertheless, the work did demonstrate that:
(1) Under a 24-hour photoperiod with sufficient light intensity, Scots pine cuttings can be rooted with minimal *Botrytis* losses; and (2) With increasing light intensity, Scots pine cuttings root faster and produce more root mass.

Table 1.—*Rooting percentages obtained with juvenile Pinus sylvestris cuttings under three light intensity regimes*

Treatment	Percentage of cuttings rooted under light conditions:[1]			
	1	2	3	X
Control	50	81	63	65
IBA	88	94	81	88
Wounding + IBA	88	94	81	88
Wounding	88	69	75	77
MycoRhiz	94	100	63	86
Wounding + IBA + MycoRhiz	94	100	88	94

[1]Light condition 1 = minimum of 5,000 to 6,000lux.
2 = bright portion of greenhouse with natural sunlight during the day and a minimum of 500 to 600 lux at night.
3 = a less illuminated portion of the greenhouse with approximately 60 percent of the daytime light intensity of 2 and a minimum of 500 to 600 1ux at night.

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